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DECADE II. VOL. VIII.

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WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

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EDITED BY

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LIST OF WOODCUTS.

THE
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No. I.—JANUARY, 1881.

ORIGINAL ARTICLES.

I.—On Genera and Species of Spiral-Bearing Brachiopoda, from Specimens Developed by the Rev. Norman Glass: with Notes on the Results obtained by Mr. George Maw from Extensive Washings of the Wenlock and Ludlow Shales of Shropshire.

By Thomas Davidson, F.R.S., F.G.S., etc.

As some fifteen months must unavoidably elapse previous to the publication of the Silurian Supplement to my work on the British Fossil Brachiopoda, it has been considered desirable to anticipate a part of its contents, relating to the recent discoveries of the Rev. Norman Glass, of Manchester, as to the spirals and their connecting processes and attachments in the Brachiopoda of the Upper Silurian rocks.

The researches of Mr. Glass, referred to in this paper, but more fully to be detailed in the forthcoming Silurian Supplement, have been long and arduous, and the important and interesting results attained are only commensurate with the skill and perseverance which he has so abundantly shown. I feel greatly indebted to him for his prolonged and valuable assistance. The first difficulty besetting Mr. Glass in his operations was the finding of suitable specimens—hundreds of examples of a particular species being sometimes needed to produce the desired result. This difficulty has been overcome through the willing services of George Maw, Esq., F.L.S., F.G.S., of Benthall Hall, Shropshire, and my cordial thanks are due to him for the most generous manner in which he has had so many tons weight of the Wenlock Shale washed, and the old quarries of Benthall Edge carefully hand-picked, for specimens. Indeed, without the thousands of specimens thus procured, many of Mr. Glass's discoveries might never have seen the light. Other valuable results of the intelligent and indefatigable help which has been rendered to me by Mr. Maw will be shown in the stratigraphical sections and lists at the close of this paper. It should be added also that in sorting the specimens needed for the preparation of the stratigraphical lists and in many important suggestions, I have been greatly aided by the Rev. H. G. Day, of Brighton, and I desire gratefully to acknowledge his devoted assistance, rendered all the more trying and difficult from the minuteness of many of the shells.

It may be well to mention here that Professor James Hall and

Mr. Whitefield have also been engaged in developing the spirals and their connections in the Palæozoic Brachiopoda, but only in American specimens, and principally in siliceous shells, or in shells possessing a hard limestone matrix. Mr. Glass's operations, however, have been confined almost entirely to English specimens, and, as it will presently appear, to those English specimens only which were partly or wholly filled with spar. Having myself most carefully studied and drawn Mr. Glass's prepared specimens I am able to assert that they do not admit of doubt or misconception, and that they completely obviate the necessity of restoration—a process which must always be associated with some degree of uncertainty.

In my Carboniferous Supplement published by the Palæontographical Society at the commencement of 1880, I gave a brief account of Mr. Glass's discovery, accompanied by figures and descriptions of the spirals of no less than thirteen species of Carboniferous *Spirifera* and *Athyris*—all of them having been worked out by the new process. Since the preparations for the publication of the above supplement were completed Mr. Glass has been engaged in investigating not only the spirals, but also their connections in the shells of the Upper Silurian formation, and also in the Carboniferous shells of the genus *Athyris*. Mr. Glass had informed me previously that his process was unsuitable for developing the connecting lamellæ of the spirals. He has proved, however, by more recent researches, and even beyond his own expectations, that it is eminently adapted for that purpose.

The new process discovered by Mr. Glass simply applies to those shells which are partly or wholly filled with spar. In all the preparations that were figured in the Carboniferous Supplement the spirals were shown in their sparry matrix opaquely, but this method would have been very difficult in developing the spirals in the small Silurian Brachiopods, and would have been entirely useless in revealing their connecting lamellæ. Mr. Glass, indeed, except in one or two instances, was unable to show the connections of the spirals opaquely even in the larger specimens. However, that which could not be shown opaquely has been successfully developed by means of transparency. When the shells have been found wholly filled with spar, both valves have been removed, and the sparry matrix scraped away on either side until the spirals were clearly to be seen by holding the specimen up against the light. In order to show the connections of the spirals, not only the matrix surrounding the spirals, but also parts of the spirals themselves, have had to be scraped away in various directions. As I remarked in my Carboniferous Supplement, previously to the discovery of Mr. Glass's process our knowledge of the spirals of the Palæozoic Brachiopoda depended upon the rare chance of finding empty shells in which these appendages were naturally preserved, or upon the equally rare chance of finding specimens in which the shell and spirals were silicified so that the latter might be developed by the use of diluted acid. In addition to these means of obtaining knowledge in relation to the spirals, there was only the difficult and generally unsatisfactory method of making sections of the hard limestone matrix by which the shells were usually filled. Now, however, and by Mr. Glass's process, there is nothing in relation to the spirals or their connecting lamellæ in the Carboniferous and Silurian Brachiopoda that may not with time and patience be discovered. Mr. Glass has ascertained that many shells partly or wholly filled with spar are met with belonging to nearly every species, and whilst it is true that in a large proportion of these the spirals are either absent, fragmentary, or broken from the hinge-plate and displaced, yet specimens having all the required conditions do occasionally occur, and there is nothing to prevent a complete and satisfactory investigation.

As I have already said, there can be no mistake as to the certainty of the results attainable under this process. When the spirals are met with in the sparry matrix of the shell either in a fragmentary condition, or broken from the hinge-plate and displaced, there may be, and there frequently are, very confusing and doubtful appearances, but as soon as the spirals are found in a perfect condition, all that was before confusing and doubtful becomes clear and certain. This more especially applies to mature shells, for in younger specimens, even when otherwise perfect, it is sometimes difficult to get a clear conception of the spirals, arising from their not having assumed their normal shape and position in the shell. In the case just supposed, where under the new process clear and certain results have been obtained, the whole of the spirals either on the dorsal or ventral side, or the whole of the connecting process in its relations to the spirals, is seen, either opaquely or transparently *in situ* and at once, and not a bit at a time, as is the case where the spirals, etc., are endeavoured to be ascertained by the cutting of sections. This Mr. Glass thinks is a great disadvantage in the use of sections as compared with his process—a disadvantage greatly increased, as it seems to him, when the sections are not made through a sparry matrix which shows the lines of the spirals, etc., in relief, but through a hard earthy limestone, in which the lines are difficult to trace through their similarity of colour to the matrix. For the details of Mr. Glass's new process, in which hydrochloric acid is an indispensable agent, readers are referred to my Carboniferous Supplement, and also to the forthcoming Silurian Supplement, which will contain a more full account prepared by Mr. Glass at my request.

In 1866, when preparing my Silurian Monograph, I found it quite impossible to procure specimens of the spiral-bearing species of the British Silurian Brachiopoda showing more than a very incomplete indication of their internal processes, nor was it possible for me to develope them on account of the hard matrix which filled the shell. Since then, thanks to Mr. Glass's great skill, I can now furnish figures showing the complete spirals, the attachment to the hinge-plate, and in most cases the connecting processes of *Spirifera plicatella*, *Sp. crispa*, *Cyrtia exporrecta*, *Meristella tumida*, *M. didyma*, *Nucleospira pisum*, *Retzia Salteri*, *Atrypa reticularis*, *A. marginalis*, *A. Barrandi*, *Glassia obovata* and *G. elongata*, all worked out in their completed shape by Mr. Glass, and showing what can be achieved by his new process. All these perfect interiors will be fully described and illustrated in my Silurian Supplement.

In these investigations it has been clearly shown that the spiral-bearing Brachiopoda can be grouped according to the way in which the spirals are connected.

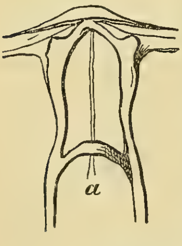
1. SPIRIFERIDÆ, *Spirifera, Spiriferina, Cyrtia, Cyrtina.*
2. ATHYRIDÆ, *Athyris, Meristella, Merista,* etc.
3. NUCLEOSPIRIDÆ, *Nucleospira, Retzia, Trematospira.*
4. ATRYPIDÆ, *Atrypa, Cœlospira, Zygospira, Glassia.*

I will now endeavour briefly to show the different characters presented in these groups from preparations developed by Mr. Glass, and principally from British Silurian specimens. These results are of the highest importance, for no good classification can be founded on external characters only, and the interior arrangements are by far the surest guides.

SPIRIFERIDÆ, King, 1850.

The spirals of *Spirifera, Spiriferina, Cyrtia* and *Cyrtina,* are all now well known. Mr. Glass worked out those belonging to *Spirifera plicatella, Sp. crispa* and *Cyrtia exporrecta,* in a very beautiful manner. We are not yet, however, acquainted with the shape of the lamella (which in all probability connected the two principal stems of the spirals) in any of the Spiriferidæ except *Spiriferina,* but I hope that Mr. Glass before long will be able to make this matter clear.

FIG. 1.



Spiriferina rostrata.

In 1851, I fully described and illustrated the spiral appendages of *Spiriferina,* their simple mode of attachment to the hinge-plate, as well as the position and shape of the semicircular lamella *a,* which connected the two spiral coils. I also showed that short spines projected from the spiral lamellæ on those parts that faced the front and lateral portions of the shell. This last-named feature has been well shown by Mr. Glass to occur also in *Athyris planosulcata* and *Atrypa marginalis.*

ATHYRIDÆ, Phillips, 1841.

This division of spiral-bearing Brachiopoda comprises several genera such as *Athyris, Merista,* and *Meristella.*

Genus ATHYRIS, McCoy = SPIRIGERA, D'Orb.

The internal characters of this important genus are now well known. The finding by Mr. Howse of a perfect empty interior of the dorsal valve of *A. pectinifera* enabled me to describe and illustrate, in a very complete manner, the shape of the spiral appendages, their mode of attachment to the hinge-plate, as well as the complicated system of lamellæ by which the two first stems of the spirals were connected. Again, in pl. xvii. of my Carboniferous

Monograph I figured the complete spiral appendages in *Athyris ambigua,* Sow. My figures had been completed from several

Fig. 2.

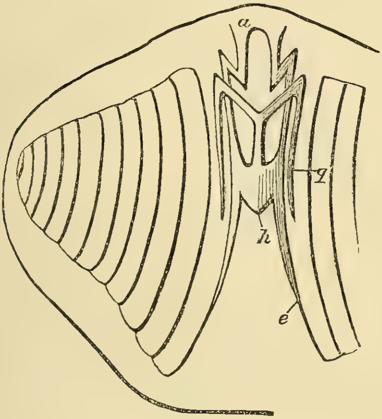
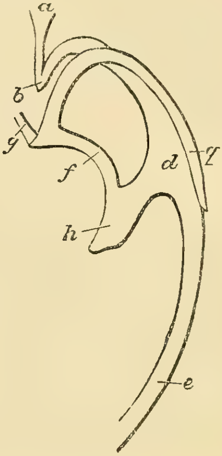


Fig. 3.



Athyris planosulcata, developed by the Rev. N. Glass.

specimens in the Museum of Practical Geology. Prof. Hall, in vol. iv. p. 289, of his Palæontology of New York, in 1867, described and illustrated the spiral appendages of *Athyris vittata,* their mode of attachment to the hinge-plate and the system of lamellæ connecting their two first coils. In the main his description and figure would agree with mine, but not quite so in details. In order that no misconceptions should exist upon the matter, the Rev. N. Glass, at my request, developed the spiral appendages and their connections in a number of specimens of *Athyris planosulcata* and *A. ambigua,* which had been liberally presented to him by Mr. John Tym, of Castleton. As will be seen from the figures here appended, drawn from Mr. Glass's worked specimens, his results would confirm the correctness of my previous illustrations.

In *Athyris planosulcata* Mr. Glass found that the first attachment of each spiral takes place at the hinge-plate *a.* From thence the two principal stems proceed for a short distance downwards, *b,* when they suddenly bend backwards forming a broad rounded curve facing the bottom of the dorsal valve *b, d, e.* At a little less than half their length at *d,* each principal stem widens and gives off a lamella *d, h,* which projects into the middle of the space intervening between the two spiral coils, and here the lamellæ are connected together and become expanded and roof-shaped. From the upper portion of the expanded and roof-shaped projection *h,* a curved lamella *f* extends upwards and bifurcating at its extremity gives off on either side a lamella *g,* which after forming a broad curve, and closely following the outer side of the first coil, ends near the place where the principal stem gives off its connecting process *q*. Indeed, Mr. Glass found in many specimens that this half coil lay much closer to the first than to the second coil of each spiral.

Now, as Mr. Glass has worked out very many specimens of *Athyris planosulcata,* and as they invariably show the same results and in the clearest possible manner, there can be no doubt as to our possession of every detail in connection with the spiral arrangements in the genus *Athyris*, especially as these preparations of Mr. Glass are fully corroborated by the specimens of *Athyris ambigua* which he also developed in a similar manner.

Genus MERISTELLA, Hall, 1859.

The working out of the spiral processes and their attachments in *Meristella tumida* does the Rev. Norman Glass the greatest possible credit. Not only has Mr. Glass been able to develop the spirals, but to take them entirely out of the shell, so that they can be examined in every direction. He has also completely excavated the inner side of one of the spiral cones, so that when held up between the eye and the light the various convolutions can be seen as a transparency. He likewise has been able to work out the attachment of the principal coils to the hinge-plate and their complicated system of connecting lamellæ. All these admirably prepared specimens will be fully illustrated in my forthcoming Supplement. As will be observed from the two diagrams here given, and drawn from Mr. Glass's specimens of *Meristella tumida,* the principal characters of the *Athyridæ* are maintained. The attachment to the hinge-plate at *a*, the short prolongation of the lamella *a, b,* its bending backwards

FIG. 4.

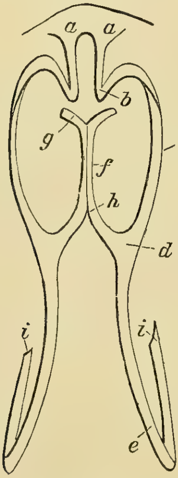
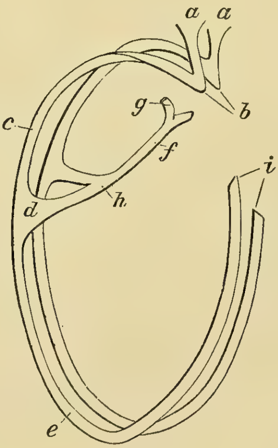


FIG. 5.



Meristella tumida, after Mr. Glass's preparations.

abruptly by a broad curve so as to form the first coil of the spiral, the giving forth at about half their length of an inwardly converging lamella *d, h,* by which both spirals are connected, the extension upwards of a narrow lamella *h, f, g,* and its bifurcation at *g,* remind us of *Athyris,* although differing in minor details, but at the point *g* the bifurcating process is short and small and does not, as in *Athyris,* give rise to a curved supplementary lamella. Now, as Mr. Glass has worked out a large number of *Athyris planosulcata* and of *Meristella tumida,* and as they have one and all constantly shown the same characters, we are justified in supposing they are persistent in each species of the same genus.

Prior, however, to Mr. Glass's researches, in vol. iv. of the Palæontology of New York, p. 298, Prof. J. Hall described and illustrated the spiral appendages, their attachment to the hinge-plate, and their connecting system of lamellæ, in *Meristella arcuata* (Hall) —a species so near in shape to our English *Meristella tumida* as to make one question whether it is not specifically the same. In Prof. Hall's figures the short forked process (*g* in our figures of *M. tumida*) extends and forms a complete circle, the branches uniting again at the point where they originated. Feeling some misgivings as to the correctness of Prof. Hall's illustration, in this particular, I wrote to Mr. Whitefield, who drew the figures, for some further explanations, and in his answer, dated the 6th of October, 1878, he says, "With regard to *Meristella* I can assure you there is no error in the figures published. Yesterday I took several of the specimens of *Meristella nasuta, M. lævis* and *M. arcuata,* and examined them; they all show the same features as given in the diagram in the text of vol. iv. Palæontology of New York. . . . They are not sections, but silicified specimens treated with acid, and the spire and loops are entirely revealed to the light. All the specimens described by Prof. Hall are now in the American Museum of Natural History." I have never seen the American specimens of *Meristella,* but I can assert that those worked out by Mr. Glass leave no room for misconception, and as they have all been most liberally presented to me by him, as well as all the other worked specimens of other species, they can be inspected by any one taking an interest in the subject. By comparing the diagrams given of *Meristella* and *Athyris,* the differences they present can be recognized better than they can be described by words.

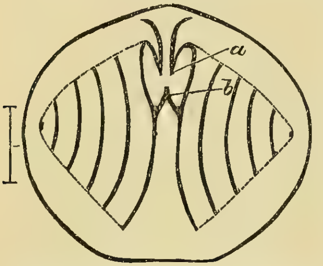
NUCLEOSPIRIDÆ.

In this group would be included *Nucleospira,* Hall, *Retzia,* King, and *Rhynchospira,* Hall. In the twelfth annual report of the Regents of the University of the State of New York, p. 24, 1859, Prof. James Hall gives a complete and illustrated description of his genus *Nucleospira,* exemplified by *Nucleospira ventricosa,* Hall.

At my request the Rev. Norman Glass has worked out in the fullest manner the characters of the spirals in *Nucleospira pisum,* their attachment to the hinge-plate, and the process connecting the spiral coils. His researches and prepared specimens agree in all important particulars with those obtained by Prof. Hall in *N. ventricosa*. *Nucleospira pisum* is one of the most abundant species in the Wenlock limestone and its underlying shales.

Each spiral is found to consist, as I had previously stated, of not more than six or seven convolutions, and the extremities of the spirals are directed towards the lateral portions of the shell. The two principal stems of the spiral coils are attached to the hinge-plate, and after extending a little way into the interior of the shell between the spirals, are suddenly bent backwards towards the hinge, and after forming a curve converge, to about two-thirds of their length, giving forth at that place short converging lamellæ, which unite in a sharp angular point, the extremity being directed towards the middle of the hinge-plate. Each of the two primary lamellæ diverge again as they proceed towards the front, and by a gentle curve form the first spiral coil. This arrangment is similar to that described by Prof. Hall in his genus *Meristina* (20th Annual Report of Regents of the University of the State of New York, revised edition, p. 186, 1868). In some specimens Mr. Glass has found the V-shaped lamellæ of which the inner branches are attached to the hinge-plate extending downwards so as nearly to meet the angular end of the connecting process, as is the case also in *N. ventricosa*. In no instance, however (and a large number of specimens have been operated upon), has Mr. Glass discovered any bifurcating process as in *Meristella* and *Athyris*.

Fig. 6.



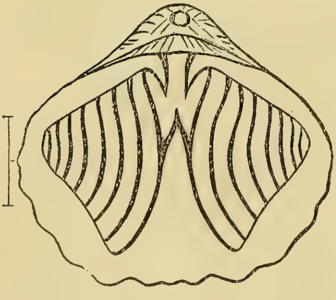
Nucleospira pisum seen from the surface facing the bottom of the dorsal valve, from preparations by the Rev. N. Glass.

Genus Retzia, King, 1850.

Nothing further relating to the type of the genus *Retzia*, viz. *Retzia Adrieni*, De Verneuil sp., is known beyond the fact that the shell was provided with spiral appendages.

Prof. Hall devotes seven pages of the Sixteenth Report of the Regents of the University of the State of New York, 1863, to the genus *Retzia* and to his genus *Trematospira*. *Retzia ? Salteri* and *R. Bouchardi* have been referred by Prof. King, myself and other palæontologists to the genus *Retzia*, and this is where I should leave them, at any rate until the internal appendages of *R. Adrieni* shall have been

Fig. 7.



Retzia Salteri, developed by the Rev. N. Glass.

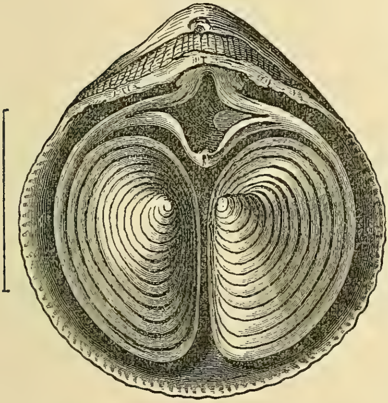
more fully determined. Nothing further than that *Retzia Salteri* was provided with spiral appendages had been discovered before Mr. Glass, at my request, worked out their mode of attachment to the hinge-plate and their connecting lamellæ. After many experiments Mr. Glass was able to show in the clearest possible manner that the spirals were attached to the hinge-plate and connected with each other in a similar manner to *Nucleospira pisum.* The only difference seems to lie in the spirals themselves, namely, that in *N. pisum* they are formed of five or six convolutions only, while about ten can be counted in each spiral in *Retzia Salteri.*

Family ATRYPIDÆ, Dall, 1877.

Genus ATRYPA, Dalman, 1828, type A. RETICULARIS, Linné.

The interior characters of this genus have been completely described by Mr. K. P. Whitefield and Prof. J. Hall. Its spiral appendages, first attached to the hinge-plate, are placed side by side, with their extremities facing the middle of the bottom of the dorsal valve, as may be seen in the accompanying Figure. Mr. Glass has also developed the complete interiors of *Atrypa reticularis* from English specimens, and his worked specimens will be fully described and illustrated in my Silurian Supplement. The principal stems of the spiral coils at a short distance from their attachment to the hinge-plate are connected by a narrow band, the branches from either side converging downwards into a V-shape, and each branch being slightly turned up at its extremity. This band seems continuous in many specimens that have been operated upon, but, as stated by Mr. W. Gurley, in some individuals this loop or band would appear to be disunited, the inner ends opposing each other without being actually connected. I must also observe that the admirably prepared specimens by Mr. Glass show that the spiral appendages in the Dudley specimens of *A. reticularis* commence by forming very large coils, but that these soon become much smaller in diameter, forming two comparatively narrow cones, and that the extremities of these cones are closer together in some specimens than in others, and that sometimes one spiral cone seems a little longer than the other, one cone, for example, showing only fourteen convolutions, whilst its companion cone has as many as sixteen.

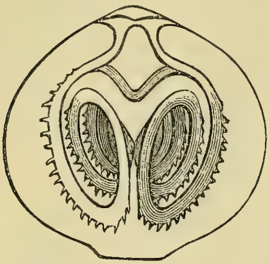
FIG. 8.



Atrypa reticularis, from an American specimen lent to me by Prof. J. Hall.

ATRYPA MARGINALIS, Dalman.

Fig. 9.



Atrypa marginalis, developed by Rev. N. Glass.

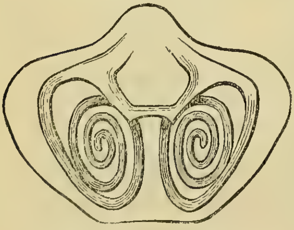
We are indebted to Mr. Glass for the knowledge we now possess with respect to the spiral appendages and connecting process in this remarkable species. The dorsal valve does not present the same degree of convexity or depth observable in that of *Atrypa reticularis*, so that the spirals are smaller, with a lesser degree of convexity. They do not show more than five convolutions, these being also more widely separated one from the other than is the case with Linnæus's species. The principal stems, as clearly seen in the two specimens developed by Mr. Glass, after being attached to the hinge-plate, are soon connected as in *A. reticularis* by a V-shaped lamella. The extremities of the spirals are close to each other and facing the middle portion of the bottom of the dorsal valve. As in *Atrypa Barrandi*, the two principal coils are not level, but slightly higher on their inner than on their outer sides.

Mr. Glass has also shown that the outer edge of each convolution, whether facing the lateral or frontal margins of the shell, gives off numerous small spiny projections in the same manner as in many examples of *Spirifer, Athyris, Waldheimia*, etc.

ATRYPA BARRANDI, Dav. sp.

During an excursion I made near Walsall in 1847, I picked up several specimens of the small species under description. Knowing nothing of its interior characters, I provisionally described it as a *Terebratula*, but subsequently I thought it might be referable to *Retzia*, on account of Dr. Lindstrom having found that the shell was possessed of spiral coils. In 1879 Prof. James Hall, at p. 162 of the Twenty-eighth Annual Report of the New York State Museum of Natural History of New York, states that the *Rh. Barrandi* seems to be very closely related if not identical with his *Cœlospira disparialis*; and in the same year Mr. Barrande, in the 5th volume of his magnificent and monumental work on the Silurian Fossils of Bohemia, describes *T. Barrandi* as a species of *Athyris*, but in his figure represents it with the spiral coils of an *Atrypa*.

Fig. 10.

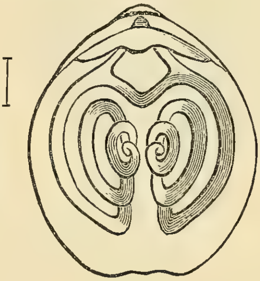


Cœlospira concava, after Hall.

It has however been left to Mr. Glass to entirely investigate and determine the interior characters of this species, so abundant and characteristic of the Wenlock Shales of Shropshire. The shell in size does not exceed some four lines in length, and the same in breadth, by three in depth, with nearly a flat or even slightly concave dorsal valve. Still, notwithstanding its small dimensions, after endless trouble Mr. Glass has succeeded in exposing in four specimens, and in the most complete manner possible, its spirals and their connecting process. These in the main agree pretty closely, although differing slightly in detail, with those of *Atrypa marginalis*, and Mr. Glass's specimens show that soon after the principal stems of the spirals leave their attachment to the hinge-plate, they give off a V-shaped lamella, by which they become connected, as in *Atrypa*.

Fig. 11.

Fig. 12.



Atrypa Barrandi, Dav., developed by Rev. N. Glass.

The principal coils however are not quite level, as in *Atrypa*. The two inner sides of these coils being slightly higher than the two outer sides, and turned towards the margin of the shell. The ends of the spires curl over to meet each other, but the amount of convexity on the side facing the bottom of the dorsal valve is very slight, because there are but four or five convolutions, and this slightness of convexity is necessitated by the very small depth of the valve. I therefore believe that the spiral arrangement in *A. Barrandi* is only a modification of that of *Atrypa reticularis* and *A. marginalis*, and with which genus *A. Barrandi* should be classed.

Genus Glassia, genus nov.

Type *Glassia* (*Atrypa*) *obovata*, Sow., Sil. Syst., pl. viii. fig. 9, 1839.

Shell marginally circular, transversely or longitudinally oval, rounded or slightly indented in front. In the interior of the dorsal valve there are spiral coils for the support of the labial or brachial appendages. The principal lamellæ forming the first coils are at a short distance from the attachment of the hinge-plate connected together by a riband-shaped lamella or loop (as in *Atrypa*). This lamella, commencing on either side from the principal coils, converges downwards in the shape of the letter V (Fig. 14), and its two extremities are sometimes slightly turned upwards before uniting. The principal coils directly face the lateral margins. The ends of the spirals meet each other in the centre of the shell, and their close apposition sometimes serves to depress and thicken the end of the spirals and to conceal the final coil on either side. The spirals, which consist of from four to five coils, are compressed, and their compressed and oval shape, together with the distance which always occurs between the base of the spirals and the lateral margins, allows the necessary room for the first convolutions. The dorsal side of the spirals is flattened, whilst the ventral side is somewhat ventricose. The spirals are closer anteriorly, but broader on the posterior side, and the principal coils on the posterior side of the spirals are slightly notched or indented, the notch or indentation being in the direction of the end of the spiral. The posterior space between the spirals is not as wide as the anterior space.

Fig. 13.

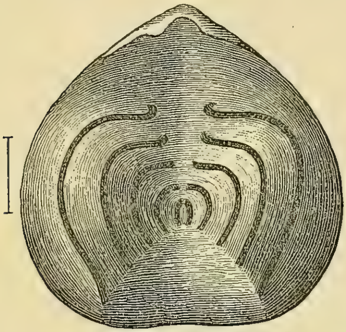
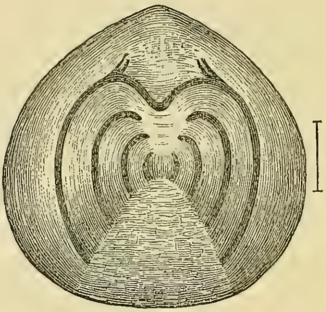


Fig. 14.



Glassia obovata, Davidson; developed by Rev. N. Glass.

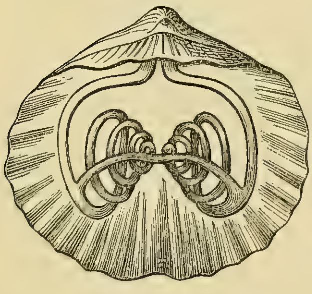
The discovery of this new genus, as well as of all its interior characters, is entirely due to the indefatigable exertions and persevering research of the Rev. Norman Glass, who, after many trials and endless trouble and patience, was enabled gradually to develop the spiral coils, their mode of attachment to the hinge-plate and their connecting process in the clearest and most unmistakable manner. I have therefore much pleasure in naming this genus after its discoverer.

The shells belonging to the genus *Glassia* are small, and both *Glassia obovata* and *Glassia elongata*, another species discovered by Mr. Glass, are common to the "Buildwas beds" (Lower Wenlock Shales), but do not occur in any great number.

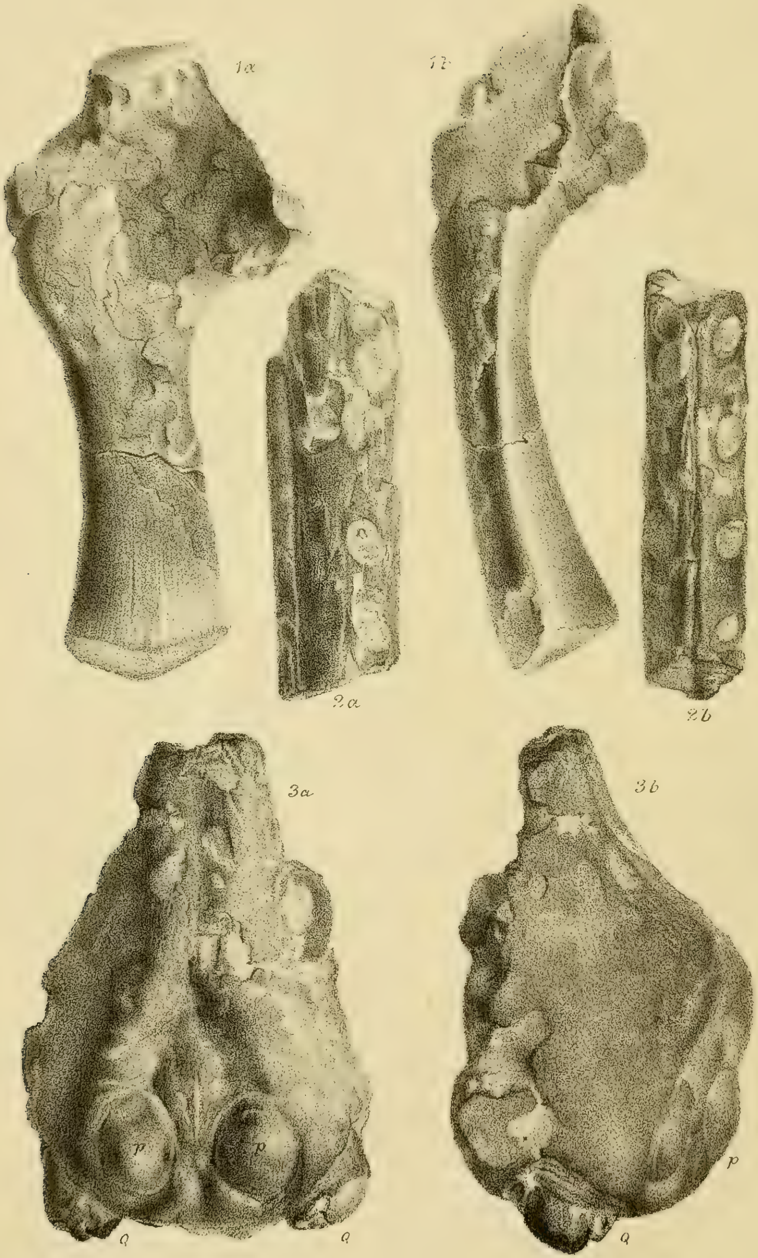
The genus *Glassia* unquestionably belongs to the family *Atrypidæ*, although it differs materially from both *Atrypa* and *Zygospira*.

Of *Zygospira*, Hall, we have not hitherto discovered any specimens in our English Silurian rocks. Prof. Hall states that its spires are nearly the same as in *Atrypa*, but differing in the presence of a strong loop or band which does not correspond in shape, position or character with the loop in *Atrypa*.

Fig. 15.



Zygospira modesta, after Hall.



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

Remains of Ornithocheirus (*Seeley*)
Upper Greensand; *Cambridge.*

In *Glassia* the spirals are connected as in *Atrypa*, but it materially differs from this genus in the direction of its spirals.

For more ample details readers are referred to my forthcoming Silurian Monograph.

(*To be continued.*)

II.—ON EVIDENCE OF TWO ORNITHOSAURIANS REFERABLE TO THE GENUS *ORNITHOCHEIRUS*, FROM THE UPPER GREENSAND OF CAMBRIDGE, PRESERVED IN THE COLLECTION OF W. REED, Esq., F.G.S.

By Professor H. G. SEELEY, F.R.S., F.G.S., etc.

(PLATE I.)

THE fragments of jaws of Ornithosaurs from the Cambridge Greensand show a greater variety in size, form, and proportion than those from any other formation. The largest species were apparently the most singular in the shape of the snout, but after five-and-twenty years of collecting we still seem destined to know them only from fragments which, though extraordinary and suggestive, are tantalizing from their imperfect condition. It is impossible to tell whether the head was short or long, or what proportion it bore to the body, in the case of these isolated specimens, but some of them, like the jaw-fragment which I am about to describe, show a power of tooth and massiveness of bone which could only have pertained to one of the most destructive and probably one of the largest of these animals.

This specimen, the anterior extremity of a jaw, was submitted to me fourteen or fifteen years ago, by the courtesy of W. Reed, Esq., F.G.S., of York, and I then made the note on *Ornithocheirus Reedii* as well as the description of *Ornithocheirus xyphorhynchus*, a jaw of a slender and altogether different type, which were included in 1870 in my book on the Ornithosauria. The specimens have again been entrusted to me, for fuller description, but they still remain unique examples of the species of which they are types. Unfortunately, only the smallest portion of the palate is preserved in *Ornithocheirus Reedii*, as though the specimen had lain snout downward in the mud, and all the bone posterior to it had decayed. This fragment of the palate is not more than a millimètre and a half long in the median line where it is shortest, but it shows distinctly a deep narrow median groove, hardly more than a millimètre wide, which expands anteriorly and divides into two branches in a V shape. This condition of a median groove in the jaw-bone has hitherto been considered, and I believe correctly, to be distinctive of the lower jaw, and I therefore propose, notwithstanding the arrangement of teeth, which led me originally to regard it as a pre-maxillary bone, now to interpret it as the anterior portion of a dentary bone. I am led to this view also by the external form, which indicates a rapid compression of the sides towards the lower part of the jaw, and also by a remarkable oblique truncation of the under side of the mandible, which is somewhat paralleled in the *Ornithocheirus machærorhynchus* (Ornithosauria, pl. xii. fig. 1). The palate, though badly preserved, was convex on each side of the median groove, and between the first pair of palatal teeth the width was twenty-two millimètres. The palatal ridges become depressed a little as they approach its anterior termination, and there appear to be a pair of small pits in front of them, external to the V-shaped termination of the palatal groove. The teeth which formed the anterior corners of the jaw [Fig. 3*b* (*q*)] are only indicated by the bases of the crowns, which were circular. Each is fifteen millimètres in diameter, or about equal to a medium-sized tooth of an Ichthyosaurus, and perhaps as large as any Plesiosaurian tooth. Each tooth is contained in a socket, which approaches within about a millimètre of a lateral wall of the jaw, and within about two or three millimètres of its anterior termination. The bone behind the tooth-socket rounds convexly from the lateral palatal inflation into the external side of the jaw, without any limiting ridge or angle. This pair of teeth was directed somewhat forward as well as upward and outward, and it may be presumed that the outward angle was determined by the inferior convergence of the lateral walls of the jaw. Behind this pair of teeth, and separated from them by an interspace of five or six millimètres, was another pair, of which only an indication of the anterior wall of the sockets remain. These show that the second pair of teeth were separated by a wider breadth of the palate. The sockets are not directed upward at quite the same angle, and that on the right side shows the fang to have been imbedded in the jaw for a depth of about thirty-five millimètres. The bony surface at its posterior fracture is black, rough, and corroded, as though by exposure on the sea-bed, and displays one or two fragments of incrusting shells. The anterior face of the specimen is triangular, formed about a right-angle apparently with the palate, and contains in its upper part the broken stumps of two pre-palatal teeth. This anterior region is about thirty-five millimètres deep, and at its widest part at the outer corners of the palatal tooth-stumps is fully thirty-five millimètres wide. The sides, which converge inferiorly, are about thirty millimètres long, and round into each other in an ill-defined way; the upper part especially of the lateral wall of the jaw rounds convexly towards the tooth-stumps in its upper part already alluded to, but it is margined by a slight ridge. The superior outline is three-sided, and consists of a middle horizontal portion, with lateral parts sloping outward and downward in front of the palatal teeth. The tooth-stumps on this anterior face [Fig. 3*a* (*p*)] are three or four millimètres below the anterior border of the palate, and are separated from each other by an interspace of less than half a centimètre. The bone of this interspace in its upper part is smooth and marked by a relatively wide and moderately deep groove, which dies away towards the palatal margin. The tooth sockets are ovate, probably from the direction of the section of the tooth, one and a half centimètre deep, and over a centimètre wide. They were probably circular, since they are seen to have been directed forward at a greater angle than the palatal teeth. The anterior space below these tooth sockets has the surface less well preserved than the upper part, but it was marked by a median inflation below the teeth, and concavities on each side, which converge to a median concavity that becomes continued on the under side of the jaw. The median oblong boss between the teeth appears to have been roughened with two longitudinal grooves, and the whole of this inferior region gives indications of rugosities, as though fleshy lips might have extended forward below the teeth, and there are no indications of blood-vessels perforating the bone, such as might have been anticipated if it had been sheathed in horn. The basal oblique truncation which forms a prolongation of this anterior region downward and backward is concave in length, a feature seen in no other Greensand Ornithosaur. It is about three and a half centimètres long, and has a shallow median groove about seven millimètres wide, which appears to become shallower as it extends backward. It is margined by convex ridges, which at first round obliquely into the sides of the jaw, but make a smaller angle with it as the jaw becomes more compressed from side to side in its backward extension. The fragment which is preserved of the lateral surfaces of the jaw shows smooth bony tissue, is concave from above downward, and nearly flat from before backward, and, as already remarked, rounds into the adjacent bony surfaces. These lateral areas are sub-rhomboid, are preserved for an antero-posterior extent of hardly more than three centimètres, while the depth of jaw indicated by the fragment is six and a half centimètres, probably a good deal short of its depth when perfect. The extreme posterior width of the specimen behind the first pair of palatal teeth is four and a half centimètres, and the width of the jaw where fractured at the posterior termination of the base is one and a half centimètre.

In 1869, in my index to the Reptilia, etc., in the Woodwardian Museum, I gave a list for the use of students of species which might be founded upon the Pterodactyle remains therein enumerated from the Upper Greensand, and I further grouped these species into two genera, which were named though not fully characterized. *Ptenodactylus* was used for twenty-one species, all more or less allied in character to the *Pterodactylus Sedgwicki* of Owen. The other genus, *Ornithocheirus*, included three species, and had for its type the *Pterodactylus simus* of Owen, it being mentioned in a note that the genus was distinguished by having no teeth anterior to the palate, a character which inferentially distinguished it from the other new genus. A month or two later, in the beginning of 1870, "The Ornithosauria" was published, and in that book I temporarily abandoned the division of the species into separate genera, not because they seemed to be incapable of definition, but because the species appeared to be capable of division into more than two genera, and I thought it inexpedient to characterize them until the whole of the evidence could be fully put forward, and supported by means of figures. The name *Ptenodactylus* was therefore abandoned and the whole of the species described were temporarily referred to *Ornithocheirus*. This genus was defined (p. 112) as having teeth prolonged anterior to the muzzle, and as having a palate with a longitudinal ridge. After giving briefly the characters of snouts or mandibles of twenty-four species in that memoir, it was remarked (p. 127), "The species which follow were separated in the Index (to the Ornithosauria, etc.) as a different genus. That proposal might still be sustained, for these massive truncated jaws are unlike the spear-shaped jaws of many of the species, and to the minds of some readers the forms already described will arrange themselves in groups which not improbably indicate genera; but a re-examination of the type *Pterodactylus simus*, Owen, has convinced me that it is a lower jaw, and therefore it affords no evidence of the presence or absence of the peculiar front pre-maxillary teeth which characterize nearly all the Cretaceous species." Since that date circumstances have delayed my intended description of these fossils in detail; but in 1874, Prof. Owen, in a Monograph on the Pterosauria, published by the Palæontographical Society, after referring to the tapering snouts which formed Von Meyer's group of *Pterodactyles* named *Subulirostres*, observed that the series might be traced to other forms in which the snout became so shortened as to be truncated; and such forms he suggested might be named *Truncirostres*. He then (p. 6) goes on to observe that the species of this family which have the foremost pair of teeth projecting forward in the upper jaw from the truncate surface at a higher level than the alveolar border form the genus *Coloborhynchus*. That there may be no mistake about the nature and limits of this genus, the species *Coloborhynchus Sedgwicki* and *C. Cuvieri* are quoted as examples. I am unable to detect any difference between Prof. Owen's definition of that genus and my previous definition in 1870 of *Ornithocheirus*; while Prof. Owen, by quoting the types which I had placed at the beginning of my enumeration of the species of *Ornithocheirus*, conclusively shows that he intends his name as a synonym. As it is not usual for any author knowingly to burden nomenclature with synonyms without justification, Prof. Owen added a note stating that he "has no evidence, and Mr. Seeley has given none, of such departure from the Pterosaurian type of hand as would justify the term *Ornithocheirus* proposed by Mr. Seeley in 1870, in his Ornithosauria (p. 112), or the term *Ptenodactylus* previously proposed by Mr. Seeley for the same *Pterodactyle* in the Index to the Fossils, etc., in the Woodwardian Museum." I certainly was under the impression that the genus had been sufficiently explained in the characters set forth in the descriptions of the skeleton between pages 28 and 94 and between pages 112 and 128 of the "Onithosauria." But Prof. Owen implies in this note that the Pterosaurian type of hand is a fixed quantity already known to him, and as I had already in previous writings expressed my dissent from the interpretation which Prof. Owen had given of the Ornithosaurian carpus, I may perhaps fairly claim that Prof. Owen is not altogether an unprejudiced judge as to what the Pterosaurian type of hand really is. It seemed to me that the carpus, as I have stated in the Ornithosauria (p. 48), consists in *Ornithocheirus* of "three bones arranged as a proximal carpal, a distal carpal, and a lateral carpal, Two of them are figured by Prof. Owen, who regarded the distal carpal as scapho-cuneiform; while a very imperfect example of the proximal carpal is named the unciform: neither of these determinations, the reverse of those that follow, were given as more than probable guesses." In "Remarks on Prof. Owen's Monograph on Dimorphodon," published in the "Annals of Nat. Hist.," for Aug., 1870, I gave a figure of the carpus and adjacent bones in the genus *Ornithocheirus*, side by side with the corresponding bones of the ostrich, such as I had been accustomed to exhibit in my lectures at Cambridge. Prof. Owen has never called in question either that nomenclature of the carpus, the restoration of it, or the reasons given for so reconstructing it; and I venture to repeat that the carpus is a portion of the hand which is, in this type, so eminently bird-like in the form and arrangement of its elements as amply to sustain the name which I gave the genus, if indeed it needed any such justification. I am therefore at a loss to understand the imputation that I have adduced no evidence which would justify the term *Ornithocheirus.* Since that date, in the Journal of the Linnean Society for December, 1876 (pp. 98 to 103), I have discussed anew the characters of the hand in *Ornithocheirus*, showing that this genus possessed three well-developed metacarpal bones, of which two were large, like the metacarpals of birds, and I am quite content, if a name can be called in question on such grounds, to leave its defence to the evidence there set forth. The Ornithosaurs, however, all have the ornithic type of hand, and make no approximation to the structure of hand seen in either reptiles or mammals. But if we are to begin calling in question the fitness of generic names, and proceed to cancel them whenever any new interpretation is supposed to make them more or less inappropriate, nomenclature will be in a constant state of flux whenever names aspire to convey interpretations of characters. Thus we have *Ceteosaurus*; there is nothing whale-like in this Saurian, it was not even an inhabitant of the water, but the name sufficiently served the purpose of indicating a type of structure which has since become better known. Similarly *Hylæosaurus*, if it means anything at all, signifies a wood Saurian; and it may be doubted whether evidence has been adduced which would justify such a name. I am not concerned to defend the name *Ptenodactylus*, because it has been abandoned in my later work; but I imagine the name might be used to indicate a "winged Saurian," without any undue stretching of meaning; and I therefore urge, that until some weighty reasons for discarding the generic names which I gave to the Greensand Ornithosaurs are adduced, there will be no need for any one to remember that the genus *Coloborhynchus* was ever instituted. I have found it necessary to make this explanation because almost the only fossil which closely resembles the species which I have here described is a species from the Hastings Sand, which Prof. Owen has described under the name *Coloborhynchus clavirostris.* From the figure it is impossible to tell whether it be a pre-maxillary or dentary bone, but from its close resemblance in some respects to this species, I suspect it will prove to be dentary. It, however, differs in presenting a nearer approximation to the type of *Ornithocheirus simus*, and it entirely wants the somewhat flattened oblique inferior area, which in *Ornithocheirus Reedii* is concave from front to back. The teeth, however, are nearly circular. The species now described differs from *Ornithocheirus capito* (Ornithosauria, p. 126), in the circumstance that the teeth in that species are elliptical.

ORNITHOCHEIRUS XYPHORHYNCHUS (Plate I. Fig. 2*a* and 2*b*).

This species was founded upon a fragment from the middle of a lower jaw, which measures 5½ centimètres in length, and must have presented an unusually dagger-like form. There is a narrow median groove running along the palate. The base of this groove is sharp, and its narrow sides diverge upward and outward, and round into the palate, so that it appears to be margined by a ridge on each side, about a millimètre wide. The palate is formed of two lateral portions, which look obliquely upward and outward, and are inclined to each other at a right angle. The width of the palate at its outer limit is 13 millimètres; the depth of the inclined lateral halves of the palate is on each side about eight millimètres. The palatal surface shows on each side four tooth-sockets, better preserved on the left side than the right. The sockets are placed on the outer part of the palate, at a distance of four millimètres from the median groove. The interspace between the first two sockets is eight millimètres, and between those which follow a trifle more. The sockets are ovate, and placed obliquely so that the anterior margin of the tooth inclines towards the inner part of the palate, and its hinder margin towards the outer limit of the palate, where the bone is elevated a little as usual.[1] The interspaces are slightly concave from front to back, and the inner and hinder border of the tooth-socket is more elevated than its anterior border. From this description it will be seen that the inner part of the palate rises as a double ridge between the teeth, and in length this ridge is very slightly concave. The sides of the jaw below the teeth round continuously into the inter-alveolar spaces, but they converge inferiorly into a blunt keel. The side below the alveolus is twelve millimètres deep in front, and increases a little in depth behind. It is gently convex and appears to be impressed in the lower part by the longitudinal groove which is parallel to the base. It is about half a centimètre from the base on the right side, and a little higher and less distinctly marked on the left side, especially in front. But for the convexity of the surfaces above and below, I should have regarded it as the result of fracture. Opposite the third pair of tooth-sockets are two holes with impressed borders apparently due to teeth of a flattened character, such as those of a Pycnodont fish. The larger of these impressions is seven millimètres long. The outer layer of bone is a good deal scaled off

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[1] The tooth-sockets are not uniformly of the same size. The earliest of the four is the smallest, and the fourth is smaller than the third. The second socket is 7 millimètres in length and 4 millimètres in width. The teeth appear to have been directed as usual upward, inward and a little forward.

from the sides of the specimen. This species nearly resembles the *Ornithocheirus Sedgwicki* of Owen, but differs in the less depth of the jaw, the greater height of the inter-alveolar palatal ridge, the much narrower palatal groove, and the greater distance between the tooth-sockets. It resembles that species in having the tooth-sockets in pairs opposite to each other, in the ovate form of the sockets, and in the compressed aspect of the jaw, though the inferior keel in this species is much more rounded. In the *Pterodactylus Cuvieri*, the lower jaw of which has not been figured, except in an anterior fragment (plate xii. fig. 5, Ornithosauria), the jaw entirely wants the slender dagger-like shape.

One of the most distinctive bones of the skeleton of *Ornithocheirus* is the scapula. In many other Ornithosaurs, such as *Dimorphodon*, the bone has a very avian aspect, but in this genus its form, though thoroughly distinctive, perhaps rather suggests the Crocodile, and as Mr. Reed's collection contains one of the most perfect specimens of this bone which I have seen from the Cambridge Greensand (Plate I. Figs. 1*a*, 1*b*), I by his kindness append a short note upon its characters.

The extreme length of the specimen from proximal to distal end is about nine centimètres. It is best preserved on the internal side, which is concave in length. The proximal end is expanded, and shows a small portion of the articular surface, but the bone there is a good deal decomposed, and all trace of its union with the coracoid, probably sutural, is obliterated. The bone also expands a little at the distal end, and the middle of the shaft, which is compressed and constricted, somewhat thickens distally. The bone terminates distally in a broad ovate flattened surface, which is smooth and moderately convex in length. The outline is rounded on the coracoid side, and compressed on the posterior margin. The extreme width of this end is about two and a half centimètres. and where thickest is about one and a half centimètre through. This surface is at right angles with the concave side of the shaft. In its most constricted middle portion the width of the shaft is about fifteen millimètres, and its thickness from the comparatively flattened under side to the more convex outer side is about twelve millimètres. The proximal end of the bone terminates in a large rhomboid mass, which is somewhat cup-shaped on the inner side. Its extreme width is about four centimètres. It is broken on both sides of the median articular surface, which is a little concave in length, and measures one and a half centimètre. Its transverse measurement is about seven millimètres, and in this direction is convex. The fracture on the outer side is probably small, since more perfect specimens show the bone here to terminate in a rounded and compressed tuberosity not greatly different in outline from that indicated by the fossil. The long fracture on the side towards the coracoid, which measures about two centimètres in length, may have removed a small portion of the bone. The lateral outline of the shaft posterior to this fracture on the coracoid side is deeply concave proximally and nearly straight towards the distal end. The corresponding posterior outline is more evenly concave. The posterior side is compressed into a nearly straight ridge, which runs along the concave margin of the bone.

EXPLANATION OF PLATE I.

Fig. 1*a*.—Internal surface of scapula of *Ornithocheirus*; the figure is placed at the proximal end, towards the coracoid margin.
,, 1*b*.—Superior margin of the same specimen.
,, 2*a*.—Lateral aspect of lower jaw of *Ornithocheirus xyphorhynchus*.
,, 2*b*.—Palatal aspect of same specimen, showing tooth-sockets.
,, 3*a*.—Anterior termination of snout of *Ornithocheirus Reedii*, seen from the front.
,, 3*b*.—Lateral aspect of same specimen, showing (p) (⌕) fragments of teeth.

All figures of the natural size.

III.—Oblique and Orthogonal Sections of a Folded Plane.

By the Rev. O. Fisher, M.A., F.G.S.

In the tenth volume of this Magazine, a correspondence appeared upon the subject of "True and Apparent Dip," which was started by Mr. Penning, and continued by several able geologists. The object of the present article is to call attention to another branch of the same subject. We are all acquainted with "Sopwith's Models," in which are experimentally shown the outcrops, or "traces," of plane strata upon variously curved surfaces. We now are about to refer to the outcrop of curved strata upon a plane surface. I was led to examine this question from the following circumstances.

Professor Prestwich, a few weeks ago, was so kind as to show me a very typical instance of the superficial deposit which I call "trail," in a railway cutting now in progress of construction near Chevening, in Kent. The cutting is in Gault, and the trail appears as coarse subangular flint gravel, unstratified, impacted in a brownish-red matrix of sandy clay, which is very similar in composition to the "clay with flints," which generally covers at a far higher level the upper parts of the North Downs. This trail, as seen in the E. and W. railway section, showed pockets sometimes four or five feet deep, and having a general oblique trend all in one direction. The natural conclusion, on a cursory examination, was that some superficial horizontal pressure acting from W. towards E. had given them this uniformity of trend. But upon viewing the sections on the south bank from the north, it appeared that the trend was exactly opposite to that of the sections on the north bank when viewed from the south. This fact, at first sight, seemed anomalous. But after a little consideration Professor Prestwich suggested to me the true explanation. The oblique trend is not necessarily real, but apparent only; and is caused by the obliquity between the direction of the furrow of trail and of the inclined plane which cuts it.

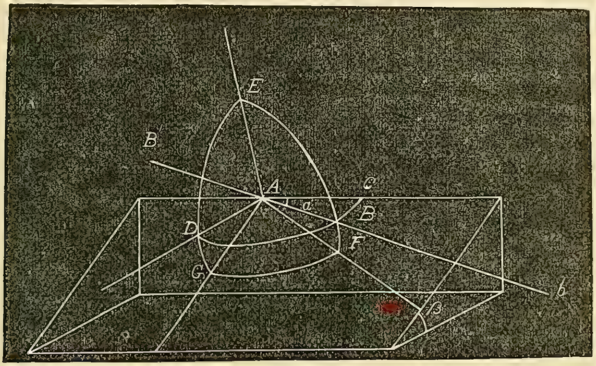
We had a model made in wood, and found that a furrow, whose orthogonal section was semicircular, gave an obliquely placed loop upon the face of the cutting plane. Of course this might have been foreseen; because it is well known that the oblique section of a horizontal round cylinder by a plane, gives rise to an ellipse, the position of whose major axis can be in a vertical plane only in one particular relative position of the two.

Let us speak no longer of trail furrows, but generally of the section of any horizontal cylindrical surface, or part of such surface, or of a folded stratum, such that its section by any horizontal plane would give a system of parallel straight lines; for it is obvious that our conclusions are unaffected by the scale on which the phenomena occur. It appears then that no apparent obliquity of trend can be given by a *vertical* section, *e.g.* by a vertical cliff, and that if any such obliquity appears in the trend of the trace, it must in that case exist in the folding of the strata themselves. But if the section be made by a plane *inclined* to the vertical like the side of a railway cutting, then, although there may be great obliquity of trend in the trace of the foldings, there need not necessarily be any in the foldings themselves.

Note.—The following is a geometrical solution of the problem:

How to delineate upon a cutting plane the trace of a cylindrical, or any other surface, which can be formed out of a folded plane.

Fig. 1.



Let $B'A\,B\,b$ be a horizontal straight line (which, for simplicity, we may consider to be the axis of a prism) parallel to the curved surface, whose trace we wish to delineate upon a given plane which cuts it.

Let $A\,C$ be a horizontal straight line, drawn upon the cutting plane.

Let the angle $B\,A\,C = a$, and let the cutting plane be inclined at an angle β to the horizon.

Draw the line $A\,E$ normal to the plane, and let it make with $A\,B$ the acute angle $E\,A\,B = \theta$. Then the angle between the cutting plane and the axis of the prism will be the complement of θ.

Describe a spherical surface about A, and let this cut the vertical plane in $E\,D\,G$, the cutting plane in $G\,F$, the horizontal plane in $D\,B\,C$, and the plane, in which lie the normal to the cutting plane and the axis of the cylinder, in $E\,B\,F$.

Then we have by spherical trigonometry, in the triangle $E\,D\,B$ which is right-angled at D,

$$\cos E\,B = \cos B\,D \cos E\,D,$$

$$\text{or } \sin\theta = \sin\alpha \sin\beta. \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Also the position of the plane of θ with reference to the horizontal line $A\,C$ is the angle $C\,A\,F = 90° - G\,F$.

$$\text{Let } C\,A\,F = \phi.$$

Then we have in the triangle $E\,D\,B$, right-angled at D,

$$\sin D\,E = \tan D\,B \cot D\,E\,B.$$

And in the triangle $E\,G\,F$, right-angled at G,

$$\sin E\,G = \tan G\,F \cot D\,E\,B.$$

But $E\,G = 90°$ and $\sin E\,G = 1$

$$\therefore \text{ eliminating } D\,E\,B$$

$$\tan\phi = \cos\beta \tan\alpha. \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

The direction in which the dimension of the trace will be the same as that of the original surface will be at right angles to the plane $E\,A\,B$, and therefore to the line $A\,F$.

The direction upon the orthogonal section of the cylinder which will be most distorted in the trace will be that in which the plane $E\,B\,F$ cuts it. Hence it will make the angle $C\,B\,F$ or $E\,B\,D$ with the horizon. Call it ψ.

From the right-angled triangle $E\,D\,B$.

$$\sin D\,B = \tan E\,D \cot E\,B\,D$$

$$\text{or } \cos\alpha = \cot\beta \cot\psi$$

$$\therefore \cot\psi = \cos\alpha \tan\beta. \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$(\text{Hence } \cot\psi \tan\phi = \sin\alpha \sin\beta$$

$$= \sin\theta.)$$

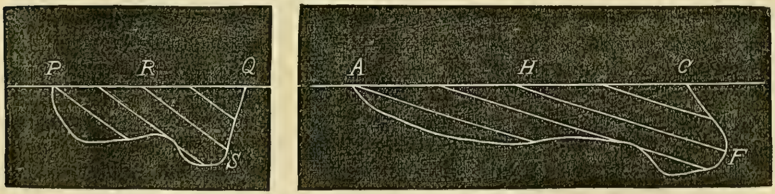
Equation (2) shows how the obliquity of the trace is inverted when the cutting plane is inclined in the opposite direction to the horizon, as upon opposite sides of a railway cutting; for in that case we must substitute $180° - \beta$ for β, and then,

$$\tan\phi' = -\cos\beta \tan\alpha,$$

$$\text{whence } \phi' = 180° - \phi.$$

If the axis of the prism should not be horizontal, but lie in a plane inclined at an angle γ to the horizon, it is obvious that our demonstration will be rendered applicable to this case also by writing $\beta - \gamma$ for β. The angle α will not however lie in a horizontal plane.

Fig. 2.



Knowing the strike of a surface, our equations,

$$\cot\psi = \cos\alpha \tan\beta,$$

$$\tan\phi = \cos\beta \tan\alpha,$$

$$\text{and } \sin\theta = \sin\alpha \sin\beta,$$

enable us to delineate its trace on any plane.

For let $P\ S\ Q$ be an orthogonal section of the surface whose trace is required. Draw $R\ S$ inclined at an angle ψ to $P\ Q$. Then $R\ S$ will be the direction in which the distortion in the trace will be greatest.

To delineate the trace, draw a horizontal line $A\ C$, and make $A\ C = P\ Q$ cosec a.

Draw $H F$ making the angle ϕ with $A\ C$. It is the direction of greatest distortion.

Divide $P\ Q$ and $A\ C$ into the same number of equal parts, and draw ordinates parallel to $R\ S$ and $H F$ respectively. Then, if the ordinates on $A\ C$ be made to bear to those on $P\ Q$ the ratio of cosec θ to unity, their ends, when joined by a curve drawn *libera manu*, will give the trace desired.

In the example (Fig. 2), it is supposed that the strike of the cylinder, or folded surface, is N.E. by N. and S.W. by S.; and that the direction of the cutting plane is E. and W., and that it is inclined at an angle 60° to the horizon.

In this case $a = 33° 45'$,
and $\beta = 60°$.

Our equations then give,

$$\psi = 34° 46',$$
$$\phi = 18° 28',$$
$$\theta = 28° 45',$$

and the trace of the left-hand figure is sufficiently correctly delineated by that on the right.

For a railway cutting, 60° would be a very high angle. In the case which we examined in Kent it was about 30°. This smaller angle would impart a much greater obliquity to the trace.

IV.—ON THE RELATION OF THE ESCHAROID FORMS OF OOLITIC POLYZOA TO THE CHEILOSTOMATA AND CYCLOSTOMATA.

By FRANCIS D. LONGE, F.G.S.

(PLATE II.)

THE Oolitic Polyzoa have been very little studied in this country. They are badly represented in our museums, and no systematic account of them has been given by any English writer. Their remains, however, are both abundant and often well-preserved in the Pea-grit beds of the Inferior Oolite near Cheltenham, and in the Forest-marble beds near Bath. Some Inferior Oolite beds near Metz, and the Forest-marble beds near Caen in Normandy, are still more prolific, and the produce of these several beds has furnished a very full illustration of the more prevalent forms of this class which lived in the Oolitic seas.

In comparing these forms with those of the living representatives of the class, we observe that while the Oolitic group contains several obsolete forms, two, at least, viz. the creeping *Diastopora* and *Alecto* (*Stomatopora*), have survived to the present time, retaining their identity in a very remarkable manner, both in respect of cell features and habit of growth. Of these two forms, we are only concerned at present with the creeping *Diastopora.* This form occupies a very different position among the living Polyzoa from that which it occupied in the Oolitic period. In the Oolitic beds it is very abundant, and represented by a considerable number of varieties; while the creeping forms are so manifestly connected by a similarity in the character and variations of their cell features with some of the common Escharoid forms of the period, that Milne-Edwards classed both groups together as different species of the same genus *Diastopora.*[1] Among living Polyzoa. the creeping *Diastopora*, although common, appears to be represented by a smaller number of specific varieties, while it presents little, if any, recognizable affinity to the Escharoid forms of the present seas. The living *Escharoids* appear rather to be connected with another group of creeping forms, the *Lepralidæ*, Busk,[2] which, although identical in habit of growth, and often associated on the same substance of attachment with *Diastopora*, are generally speaking distinguishable from that form by a marked difference in their more characteristic cell features; a difference which has been made the basis of distinction between the two groups or sub-orders called the *Cyclostomata* and the *Cheilostomata.* According to this division, the *Diastoporidæ* belong to the *Cyclostomata*, and the *Lepralidæ* to the *Cheilostomata.* And it follows that, if this principle of classification is to be applied to the Oolitic Polyzoa, the Escharoid forms of that period, which Milne-Edwards determined to be *Diastoporidæ*, must be assigned to the *Cyclostomata*; while the Escharoid forms of the present seas, the *Escharidæ*, or, as Hincks designates them, the foliaceous *Lepralidæ*, etc.,[3] are by all systematists classed with the *Cheilostomata.* But it is clear that the Escharoid forms, whether they appear in the Oolitic or any subsequent group, have a marked feature in common, which, if it does not imply generic affinity, at all events distinguishes them from all other calcareous forms, viz. the peculiar mode in which the foliaceous lamellæ, of which the cœnœcia consists, are formed by the growing together of two layers of cells, placed back to back.

If then, this principle of classification is sound, the similarity in the structure of the cœnœcium in the Escharoid forms must be regarded only as a coincidence in the development of form in two distinct races. And there would be no objection to such a view, if the Escharoid forms, as exhibited in these different periods, presented a difference in cell feature corresponding to the different characteristics of the two orders. It is perfectly clear, however, that some of the Oolitic *Escharoids* themselves possess the characteristic cell features of the *Cheilostomata* in a marked degree; and their affinity to the Cheilostomatous *Escharidæ* has been recognized by no less authorities than D'Orbigny[4] and Michelin.[5] Assuming then that this principle

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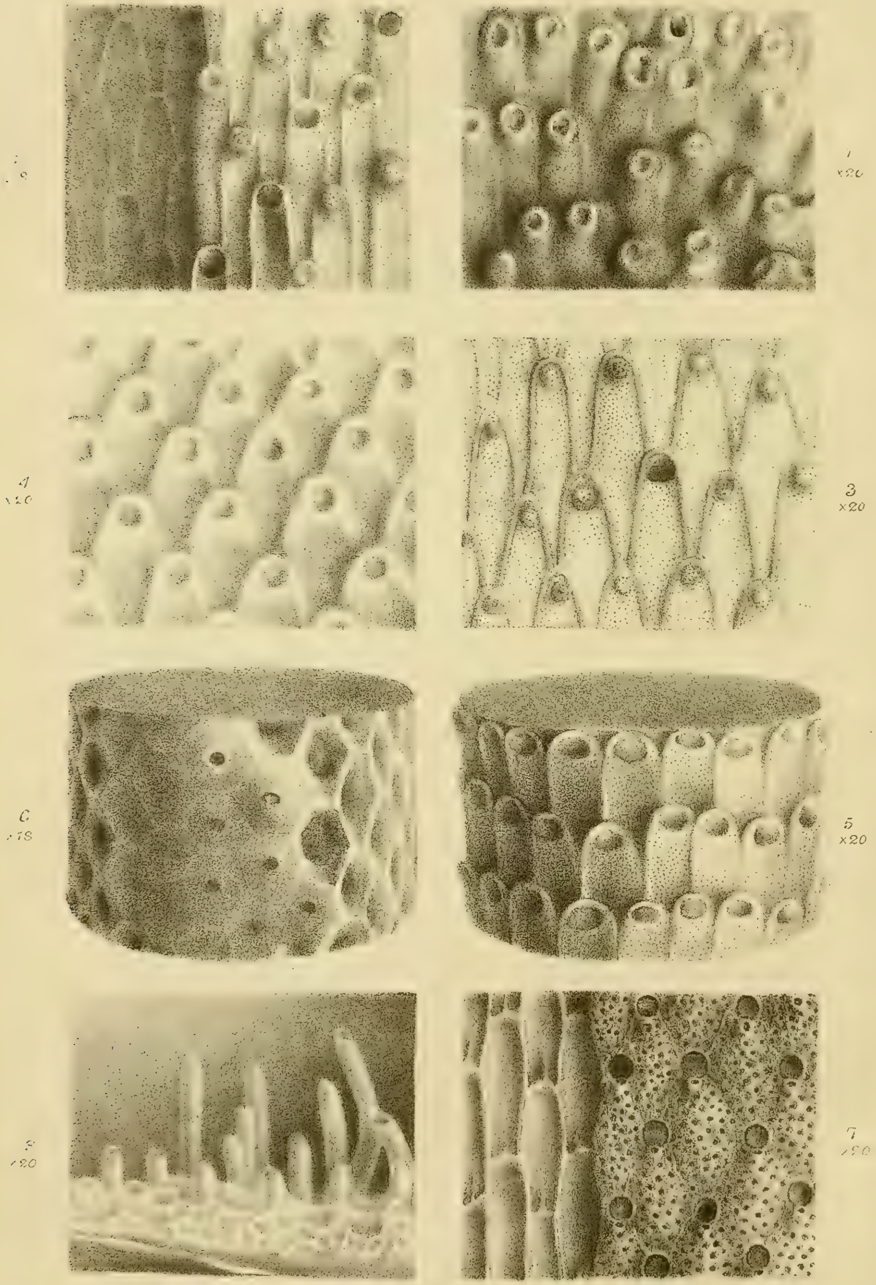
[1] I have a specimen of an Oolitic *Diastopora* which, after incrusting a nodule, has just commenced a bilaminate upright growth. See Busk's Fossil Polyzoa of the Crag, p. 109.

[2] See Fossil Polyzoa of the Crag, p. 63.

[3] British Marine Polyzoa, *Lepralia foliacea*, p. 301.

[4] Paléontologie Française—Terraines cretacés.

[5] Iconographie, Zoophytologique.



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

Escharoid forms of Oolitic Polyzoa.

of classification is sound, the Oolitic *Escharoids* themselves must be divided between two different orders. If, on the other hand, their study proves generic affinity between the whole group, we must look in another direction for an escape from the dilemma.

The weight of the evidence which these forms present of being closely allied, either as different species of the same genus, or as mere varieties of the same species, can only be fully appreciated by an examination of the forms themselves; but it is sufficient evidence of such affinity that Jules Haime, the only student of these forms that I am aware of, who has written a systematic account of them, was so convinced of their generic identity that, notwithstanding D'Orbigny and Michelin having expressed different views as to many of them, he classed them all as *Tubilipora*,[1] a division corresponding to the *Cyclostomata* of later authors; and he did this in face of the objection, that, according to such a view, the *Cheilostomata* (or, as he called them, the *Escharidæ*), which were so abundantly represented in the Chalk, must have originated, not by any modification of corresponding Oolitic forms, but either by a new creation, or by a process of development from some obscure form, which took such a rapid and remarkable course as to produce in the very next period a number of Escharoid forms so similar in their character and even cell feature as to be undistinguishable from the Oolitic *Escharoids* by such observers as D'Orbigny and Michelin.

A reference to the points of doubt or dispute raised by these authorities, in their attempts to apply this system of division to these Escharoid forms as are represented in the Oolites and the Chalk, will show at once the gist of the question raised. D'Orbigny figures and describes a Cretaceous form very similar to some of the Oolitic species, first as an *Eschara*, in his order Cellulines; and afterwards as an *Elea*, in his order Centrifugines. He did not, however, make this change in the classification of this form until he had introduced into his system a sub-order which he called the Centrifugines Operculines, *i.e.* forms which combined the tubular cell of the *Cyclostomata* with the operculum of the *Cheilostomata*. To this sub-order he assigns two families. 1. The Eleidæ, embracing several of the ambiguous Escharoid forms common to the Oolites and the Chalk—and a dendroid form, *Melicertites*, also common to these two groups. 2. The Myriozoumidæ, in which he placed the genus *Myriozoum*—a living genus the ambiguous character of which is recognized by recent authorities.[2] In his account of the Oolitic Polyzoa, Jules Haime, in dealing with one of the forms classed by D'Orbigny as an *Elea*, refers to D'Orbigny's view as to its possessing opercula, but rejects it at once as a mere error of observation, suggesting that what D'Orbigny took for opercula was merely a disfigurement of the cells in a badly-preserved specimen. As, however, the lids or closures which D'Orbigny determined to be opercula are very evident in the best-

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[1] Memoirs de la Société géologique de France, 1854, Description des Bryozaires fossiles de la formation Jurassique.

[2] See A. W. Waters, Bryozoa of the Bay of Naples, Ann. and Mag. Nat. Hist. vol. iii. 1879; also Journ. R. Microscop. Soc. vol. ii. xxiv.

preserved forms, Haime's explanation is valueless. Nor can it be supposed that such an observer as D'Orbigny would have gone the length of establishing a distinct group, embracing several foliaceous and dendroid forms, common to the Oolites and the Chalk, if he had not strong evidence of the presence of opercula in the cells as well as of their tubular forms. The difference of opinion among these authorities as to the character of many of these forms is undoubtedly to be attributed to the important fact that most of them exhibit a very different character of cell feature in different parts, even of the same lamella. The Escharoid forms of the Oolites may be divided into three groups. In one group, the cell structure is very irregular, some of the cells are immersed, with their orifices immediately on the surface of the lamella; other cells close by are protruding.[1] In another group the protruding cells disappear, but the immersed cells are irregular in length and form, and irregularly arranged.[2] It is in lamellæ of this character that I have observed the lids which D'Orbigny regarded as opercula in such a state of preservation as to show that they possess the same punctured texture as the surrounding cœnœcium. Such evidence, if it does not prove these lids to be opercula, disposes satisfactorily of the suggestion that they are the effects of decay, or the mere filling up of the cells by crystallization.[3]

In the third group, the cells are more uniform, and so regularly arranged as to produce the quincunxial symmetry and angular areolation so characteristic of the Cheilostomatous *Escharidæ* of the Chalk. These forms are represented by the *Eschara Ranvilliana* of Michelin,[4] and other varieties. No unprejudiced observer can doubt the Cheilostomatous character of this form. Jules Haime, however, was compelled by his principle of classification to deny it such attributes, and accordingly gets over the difficulty by identifying it with another form, which he called *Diastopora lamellosa*, a form in which the Cheilostomatous character was much less shown.

If we refer to Hagenow's account of the Polyzoa of the German Cretaceous beds,[5] we find that while recognizing the existence in these deposits of the Escharoid forms which Milne-Edwards had classed as *Diastoporidæ*, he does not figure or describe any specimens himself. The only figure of a *Diastopora* of any kind which he gives is a creeping form of the common type. This figure appears in a plate containing Urceolate or Cheilostomatous forms, and he states that he had originally classed this Cretaceous *Diastopora* as an *Urceolate*, but that he had transferred it to the *Tubilipora*, on the authority of Milne-Edwards that *Diastopora* has no operculum. As he took no further notice of the Escharoid *Diastoporidæ*, he avoided discussing D'Orbigny's view as to the operculum. The only Escharoid forms which he himself describes are entered in his list as *Escharidæ* in his

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[1] See Fig 1, Plate II. Also plates to Jules Haime's memoir, and in Michelin's and D'Orbigny's works above cited, illustrating *Diastopora*, *Bidiastopora* and *Mesenteripora*.

[2] See Figs. 2 and 3.

[3] Lids similarly punctured are visible in the non-protrudent cells of other kinds of Oolitic Polyzoa when well preserved.

[4] See Fig. 4.

[5] Die Bryozoen der Maastrichter Kreidebildung.

family *Urceolata*. But it is clear that the only reason of which he was aware for separating these ambiguous Escharoid forms from the rest of the *Escharidæ* was that, according to the authority of Milne-Edwards, the *Diastoporidæ* had no opercula, and therefore must have belonged to the other family or order. It may be observed that he had not ascertained this himself, for he had actually classed *Diastopora* with the *Urceolata*. But had Hagenow examined the recent *Diastoporidæ* for himself, he would have found that while they present a corresponding irregularity of cell feature to that of the Escharoid forms, which Milne-Edwards and Jules Haime assigned to the same genus, they exhibit operculoid lids in many of the cells, punctured in a similar manner to those which D'Orbigny observed in the forms which he classed as *Eleidæ*. Why are not these lids opercula? I submit that there is absolutely no reason for disputing their complete homology with the opercula of the *Cheilostomata*, except that the absence of such an apparatus in the mouth of the cell has been put forward (apparently on the authority of early observers) as the principal feature by which the *Cyclostomata* are distinguished from the *Cheilostomata*.

How the lids which close some of the cells in *Diastoporidæ* were either not observed or their presence ignored by early systematists is easily explained. According to the definition of the *Tubuliporina* given by Johnston,[1] which, with an immaterial modification, has been adopted by Busk, the absence of opercula is stated to be an essential characteristic. The Cyclostomatous cell is defined in Busk's Synopsis of the Primary Divisions of the Polyzoa.[2] to be "tubular, orifice terminal, of the same diameter as the cell, without any movable apparatus for its closure."

Now it is perfectly true that the more prominent and visible cells in the *Diastoporidæ* are of the typical tubular form as above defined, and they sufficiently demonstrate the connexion between *Diastopora* and other tubular-celled forms for the purpose of classification. It is, however, very clear that nearly every cœnœcium, particularly of *D. patina*, Busk, contains other cells of a very different character and pattern, so much so, that the observation of a few specimens will show that this definition of the cyclostomatous cell only applies to some of the cells in this form. It will be observed that besides the prominent tubular cells, there are some cells decumbent and much immersed, which have a fusiform or elongated oval shape, and that these cells are closed by lids or shutters of the same form and character apparently as the opercula in many of the *Lepralidæ*.[3] To these cells this definition does not apply any more than to the cells of many of the Cheilostomatous forms.

Although these closed cells appear to have been unnoticed by earlier observers, they have not escaped the observation of later students. Professor Busk himself recognizes their existence in *Diastopora patina*; and Mr. Hincks mentions them as occurring in this and other species of living *Diastoporidæ*. Johnston, however,

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[1] Johnston's British Zoophytes, vol. i. p. 262.

[2] Preface to the Fossil Polyzoa of the Crag, p. 9.

[3] See Fig. 8.

although he gives a full account of all the forms of which he treats, makes no mention of them. It is clear, I think, that they were not discovered, or, at all events, taken any notice of, until long after the principle of classification in question was established. Their discovery would not necessarily interfere with the classification of the living Polyzoa, as the living forms classed as *Cyclostomata* are generally sufficiently distinguished by their calcareous constituency, and the simple tubular shape of their characteristic cells, from most, if not all, of the living families classed as *Cheilostomata;* but it does directly challenge the soundness of the principle on which this division is based.

This definition of the *Cyclostomata* can only be reconciled with the existence of these operculoid features in the *Diastoporidæ*, if, notwithstanding their apparent homology with the opercula of the *Cheilostomata*, these lids have really some function and *raison-d'être* altogether different. But, if we refer to Professor Busk's and Mr. Hincks's account of the recent *Diastoporidæ*, we shall see that they offer no satisfactory reasons whatever for distinguishing these lids from the opercula of the *Cheilostomata.*

In his description of *Diastopora patina*,[1] Professor Busk thus refers to the two kinds of cells presented by this form: "Central cells immersed, and usually closed, marginal ones erect and open." As to the nature of the lids by which the central cells are closed, Professor Busk offers no suggestion.

In his account of the same species, Mr. Hincks thus describes the cells: "Zoœcia stout, minutely punctate, crowded; in the central portion of the colony immersed and closed, disposed in radiating lines; towards the margin usually erect, open; orifice in the central cells sub-elliptical, plain; in the marginal cells, sub-orbicular."[2] As to the closed cells, Mr. Hincks observes: "It is difficult to determine what is the precise function of the closed cells which occur in such numbers in every colony. Smitt has suggested that they may be connected with the production of spermatozoa, and notes that in *Tubulipora patina* there is sometimes a small tubular opening in the cap or operculum analogous to the projecting process in *Diastopora Sarniensis*. It may be objected to this view that the closed cells are so numerous as to be out of all proportion to the function assigned to them, but it would be difficult to suggest a better interpretation, and it will do good service by giving direction to inquiry."[3]

In his account of *D. Sarniensis*, Mr. Hincks thus describes the cells: "Zoœcia stout, generally free and sub-erect for a considerable portion of their length; orifice elliptical, occasionally *closed by an operculum*, from the upper part of which a small tube projects."[4] As to the operculate cells, he says: "The precise significance of the zoœcia (some of which are to be met with in each colony), which are operculate and furnished with a small tubular process at the top, is unknown. They have been conceived to be subservient to repro-

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[1] Catalogue of the Cyclostomatous Polyzoa in the British Museum.

[2] British Marine Polyzoa, p. 458.

[3] *Ibid.* p. 460.

[4] *Ibid.* p. 463.

duction, and to be equivalent to ovicells, but *D. Sarniensis* is provided abundantly with oœcia of the usual character, a fact which must throw doubt on this interpretation."[1] It is to be observed that in this passage Mr. Hincks has not hesitated to adopt Smitt's term "operculæ" as applicable to the lids which appear in this species of *Diastopora*.

Mr. Hincks's description of the cells in the common form *D. obelia* is as follows: "Zooecia moderately slender, minutely punctate; surface flattened, usually with only a short portion of the anterior extremity free and sub-erect orifice sub-circular."[2] To this he adds in his further remarks on the species: "In some cases many of the cells are closed at the top, but they are never furnished with the tubular process which occurs in *D. Sarniensis*." With reference to this tubular process in the opercula of *D. Sarniensis*, Mr. Hincks has this important note: "Busk mentions a minute central perforation as occurring in the calcareous lid with which the cells are furnished in *Mesenteripora*."[3] Now it so happens that *Mesenteripora*, Blainville and Busk, is one of the generic names given to some of these very Escharoid forms, the character of which we are discussing. I shall not complicate my argument by suggesting any theory as to the "central holes," nor as to the "tubular processes." But the apparent connexion between these features furnishes further evidence of the connexion between the "calcareous lids" of the Oolitic Escharoids and the "opercula" of *D. Sarniensis*.

These passages show conclusively that the cœnœcia of the *Diastoporidæ* contain cells closed with lids of some kind, while they suggest no better ground for distinguishing them from the opercula of the *Cheilostomata*, than Jules Haime did for rejecting D'Orbigny's view as to the opercula of the *Eleidæ*. The only grounds which appear to have been suggested are that the cells in which they are seen are different from the cells occupied by the living zoids; or that the lids themselves show evidence of being fixed, and so not usable as opercula. But Mr. Hincks evidently failed to satisfy himself that the cells in which they appear had any different character or function from those in which they do not appear. As to the suggestion that they are "doors" which did not open, the number of the closed cells in many cœnœcia is altogether opposed to the view that they are only the fixed coverings of abortive cells. That these lids should become thicker and more calcareous with age, and remain permanently fixed after the absorption of the zoid, would be quite consistent with their having been movable during its life.

The shape and position of these lids in the orifices of the shell is identical with that of the opercula in some of the recognized Cheilostomatous forms. It appears from Mr. Waters' account of the opercula of the *Lepralidæ* that the greatest variety exists in this single group in the form and position of the operculum, and as to the mode in which it is attached and moved. The more perfect arrangement of a door or shutter fitted to the outside rim of the orifice by a visible hinge and muscle, is by no means universal. In some cases the

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[1] *Ibid.* p. 464. [2] *Ibid.* p. 462. [3] *Ibid.* p. 460.

operculum is said to be attached to the cell wall merely by a portion of its own membrane remaining fixed, and in some cases the operculum is placed in the interior of the cell, "deep down in the throat."[1]

It is evident from this account of the different character of the opercula in the *Lepralidæ* that the question whether these lids in *Diastopora* are or are not true opercula, cannot be determined merely by the non-detection of any visible hinge in the cell wall, or other accessory apparatus for moving them.

While then these authorities fail to furnish any grounds for denying an operculated character and function to these features, I submit that the consideration of the mode in which they make their appearance in the *Diastoporidæ* affords as good evidence of their being opercula, as the conditions in which they appear in many Cheilostomatous forms.

I may mention here that, though I wish to avoid resting my argument on any unsupported observations of my own, I am quite satisfied from examination of specimens of *Alecto granulata*, and other living species, that lids of the same character as those in *Diastopora* are to be found in the less exsert cells of other tubular forms. In the specimens which I have examined some of the cells are distinctly closed with transparent lids, while their previous existence in others is shown by their remains giving a jagged appearance to the interior edge of the orifice. The cells in which they are present are only distinguishable from those in which they are not visible, in being shorter or more immersed, and in having their orifices exposed nearer to the surface of the cœnœcium. Such observations suggest that their appearance in some cells, and their absence in others, depends simply upon the extent of the oral prolongation of the cell, and would be fully explained if these lids were opercula. Such an apparatus would naturally be placed immediately above the zoid when retracted, and if placed in such a position in the decumbent and shorter cells, it would appear as a lid covering the orifice. It might or might not be present in the longer tubes; but if it were present at the same position relative to the zoids' body, it would be so "deep down in the throat" as to be invisible. I am indebted to Mr. Waters for the information that in *Entalophora rugosa*, a dendroid form, in which the tubular cells are much extended, they have been found to be closed internally by "a disk, somewhere about where the tube goes out of the cœnœcium." This position agrees fully with that which the lids in *Diastopora* occupy in the shorter and decumbent cells. It is possible that opercula may be present in the shorter cells, and altogether absent in those in which the oral extremity is prolonged. Such coverings are clearly not so much wanted in long tubular cells as they are in the shorter cells, where the proximity of the orifice to the body of the zoid when retracted would render the cell a very imperfect covering unless it was closed or roofed in. And it would appear to be much more reasonable to regard the opercula as features common more or

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[1] Proceedings of Lit. and Phil. Soc. vol. xviii.

less to the whole class, and capable of being developed in some form or other by any species, than to regard such a mere appendiculate organ as the exclusive property of one primary division of the class.

In a specimen of *D. patina* which I have before me, the difference in the shape of the closed cells and those with open orifices is very marked.[1] The latter are cylindrical tubes which rise free from the cœnœcium at right angles to the surface from which they spring; the former are decumbent, having their upper parts only slightly elevated above the surface of the cœnœcium in which the rest of the cell is immersed. The orifices of the protuberant cells are simply the round extremities of the tubes; the orifices of the decumbent cells are oval or elliptical.

The difference in the shape of the orifices in the two kinds of cells is evidently due to the difference in the direction of their growth. If a conical tube is truncated, at right angles to its axis, the section made is round; if it is truncated in any other angle, the section made is more or less elliptical, according to the angle made by the plane of truncation with the axis of the tube. This principle would seem to afford a sufficient explanation of the difference in the shape of the orifices in the erect cells, and of those in the decumbent or semi-erect cells, in *D. patina*, and to be more or less illustrated by the variation in the shape of the orifice in many other cœnœcia, belonging both to Cyclostomatous and Cheilostomatous forms.

But the difference in the shape of the erect and the decumbent cells in *D. patina* is the recognized distinction between the tubular shape of the Cyclostomatous cell and the oval shape of the Cheilostomatous cell; and if the appearance of these two types of cell form in the same cœnœcium is considered in connexion with the evidence which the Oolitic Escharoids furnish, first of a similar combination of these different cell forms in the same lamellæ, and secondly of the gradual disappearance of the protuberant cells, and the development of the typical cell features of the Cheilostomata in the same group of forms, the problem which puzzled the authorities to whom I have referred above in dealing with these forms is solved. The decumbent cells in *Diastopora* may be regarded as ancestral Cheilostomatous cells, and *Diastopora* itself as the parent stock from which many, if not all, of the families of the Chalk and subsequent periods, grouped as *Cheilostomata*, have been derived.

In speaking of the oval shape as typical of the Cheilostomatous cell, I am fully borne out by Professor Busk's description of the two types in his introduction to the Crag Polyzoa. It is, however, important to observe that Johnston defines the cell of the *Celliporina* (the group which in his system embraces the greater portion of the *Cheilostomata* of later systematists) as being "oblong or oviform." He evidently introduced the term "oblong" to meet the case of the *Escharidæ*. The principal representative of this group among living forms is unquestionably *Eschara foliacea*, and it is clear that the cells in this form are rather fusiform and oblong than oval. The cells are

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[1] See Figure 8.

of a long oval shape when young, and they become oblong in the older or lower parts of the lamellæ through the compression of cœnœcic growth[1] Hincks describes the cells in this form, which he calls *Lepralia foliacea*, as "ovate-elongate or rhomboid," and he further says: "The zoœcia are liable to some variation in form, and are often much elongated and sub-quadrangular." The similarity of cell form in some of the Escharoid *Diastoporidæ* of the Oolites to that of *Eschara foliacea* is very striking.[2]

Among the various modifications which distinguish the so-called *Cheilostomata* from the *Cyclostomata* is the increased use of organic material, of a membranous or horny consistency, in the composition and structure of the cœnœcium. Modification in this direction is exhibited in some species by the avicularia and vibracula, which would appear to be developed from the opercula themselves by a process of adaptation.[3] That the opercula of the recognized Cheilostomatous forms should be of a purely membranous or horny constituency, while the opercula of the more calcareous cœnœcia of the *Cyclostomata* should be of a membrano-calcareous composition, capable of being preserved in fossil remains, would be quite in accordance with this change of character in the composition of the cœnœcium. It would appear that even in some of the Oolitic forms, where the shape of the tubular cell was modified so as to present an expanded oral extremity, the membrano-calcareous integument developed to cover the orifice was not all movable as an operculum, but a small oral aperture was formed in the centre,[4] while the rest of the integument became an integral part of the cell walls.

If the view here suggested as to the connexion between the Cheilostomatous and Cyclostomatous cell features is correct, there can be no difficulty in determining the true morphological and genealogical position of the Oolitic *Escharoids*. Jules Haime was right in assigning the whole group to the same genus as *Diastopora*. D'Orbigny was right in asserting the existence of opercula in some of these forms. Michelin was right in asserting the affinity of some of them to the Cheilostomatous *Eschara*. These ambiguous Escharoid forms, as represented in the Oolites, are to be regarded as exhibiting complete evidence of the transformation of the simple tubular cell of the older forms into the variegated cell forms of the *Cheilostomata*, and of the close affinity between a number of families which has since been obscured by divergent development.

If such views are correct, it will follow that the system of classification which is based on the supposed absence of opercula in a primary division of the whole class must be abandoned, and the classification so modified as to recognize the affinity of several families now classed as members of distinct orders.

The following is submitted merely as a suggestive sketch of the genealogical arrangement of certain families which this view would authorize:—

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[1] See Fig. 7.

[2] Compare Figs. 2, 3, 7.

[3] Hincks, British Marine Polyzoa, Introduction, p. lxvii.

[4] See Fig. 6.

Race: DIASTOPORIDÆ.

Families or genera represented in the Oolites:

Creeping: *Diastopora;*
Foliaceous: *Bidiastopora; Mesenteripora*, etc.; *Elea; Eschara.*
Dendroid: *Cricopora; Melicertites; Entalophora*, etc.

Familes or genera represented in the Chalk and subsequent periods:

Creeping: *Diastopora; Lepralia*, etc.; *Cellepora*, etc.
Foliaceous: *Mesenteripora; Eschara*, etc.
Dendroid: *Entalophora; Myriozoum; Vincularia*, etc.

EXPLANATION OF PLATE II.

Figures 1 to 6 are taken from Oolitic forms. They represent small portions of surface, about 2 × 1½ mills., magnified about 20 diameters.

Fig. 1 belongs to an Escharoid form having a similar growth to that of the living *Eschara foliacea*, Lamk. Busk, etc. It developes large lamellæ of an irregular rectangular shape, which anastomosing together at right angles form hollow-chambered masses of upwards of a foot in dimension. The cell texture is essentially that of *Diastopora.* Some of the cells are decumbent, and confined within the general surface of the lamellæ. Others have their oval extremities protruding and tubular. The orifices of the decumbent cells are generally round with thick rims or peristomes. The specimen figured has retained too little of the original surface to afford much evidence of opercula.

This species would probably be classed by D'Orbigny as a *Bidiastopora.* It is very like *D. Lamourouxi* of Haime. The type is common in the Pea-grit of Cleeve Hill.

Fig. 2 is also an Inferior Oolite form from Cleeve Hill. I have identified it with a specimen in the Cambridge Museum, named by Haime *D. Wrighti.* The specimen figured is in good preservation, retaining its white calcareous surface, and showing the characteristic punctation of the *Diastoporidæ* in the cœnœcium, and in the lids which appear in several of the cells. It differs from Fig. 1 in having the cells more regularly arranged, and more evenly laid on the lamellæ. The orifices are rimmed like those of the decumbent cells in Fig. 1. In parts the cells show a slight tendency towards protrusion. The cell margins, formed by the coalescence of adjoining tubes, are seldom very prominent; but they appear very distinctly in parts where the surface has been abraded, and the similarity of the structure and arrangement of the cells to that of the living *Eschara foliacea*, Fig. 7 is very apparent. This form would probably be classed as an *Elea* by D'Orbigny, and as *Mesenteripora* by Blainville and Busk.

Fig. 3 is also an Inferior Oolite form. The cells are all decumbent and much depressed, margins very prominent in parts. The orifices are sunk or thin rimmed. In several of the cells they are clearly sub-terminal, as in the typical Cheilostomatous cell. In this specimen the original punctured surface is well retained, both in the lids closing the orifices, and in the surrounding cœnœcium. This form shows a further advance towards the Cheilostomatous type, the tubular shape of the cells exhibited in Figs. 1 and 2 being much less maintained.

This form is very like *D. Mettensis* of Haime. It would probably be classed as an *Elea* by D'Orbigny.

Fig. 4 is from the Forest-marble beds at Luc near Caen in Normandy. These are the same beds as those of Ranville, from which so many of the best specimens of the Oolitic Polyzoa have been obtained.

In this form the modification of the tubular cell is carried still further, Longitudinal compression, producing a lateral bulge, has transformed the tubular into the oval shape, while the regularity with which the cells are arranged, and the prominence of their margins, produces the symmetrical areolation which is so characteristic of the Cheilostomatous Escharoids. The orifices are round and rimmed. The symmetrical character represented in the figure is only confined to parts of the cœnœcium. In other parts the shape and arrangement of the cells is sufficiently irregular to show its affinity to *Diastopora.*

I have little doubt but that this form is the *Eschara Ranvilliana* of Michelin. In his figure the areolation is slightly more angular than in the part shown in the figure. Jules Haime has classed a somewhat similar form as *D. lamellosa.* D'Orbigny's *Eschara* or *Elea triangularis* is evidently a very similar form.

FIG. 5 belongs to a group of dendroid forms very abundant in the Oolites. The specimen from which the figure is taken is probably *Spiropora cæspitosa* of Haime. The group bears several other generic names, such as *Cricopora, Intricaria, Entalophora, Idmonea*, etc. The shape and character of the cell varies much in the same cœnœcium or plant. The change from the tubular to the Cheilostomatous type is exhibited in this group by the same gradation of shape as in the Escharoids, but the variety of shape assumed is different. In many of the specimens the punctured surface of the cœnœcium and cell lids is well preserved.

FIG. 6 is taken from another dendroid form, which exhibits an extreme modification of the tubular cell. Its peculiar character is evidently due to the cells growing almost at right angles from the centre to the surface of the stem, and expanding as they grow. This mode of growth produces a very enlarged orifice, too large to be covered by an ordinary operculum. It is accordingly covered with a fixed membrano-calcareous integument, in the centre of which a small secondary orifice is provided.

This specimen is from the Inferior Oolite beds at Arromanches, in Normandy. It would apparently be classed as a *Laterocea* by D'Orbigny and as *Melicertites* or *Escharites* by other authors; see Hagenow's *Salpingia.* The cell growth and arrangment is much the same as that of *Myriozoum.*

FIG. 7 is taken from the common *Eschara foliacea* of the present seas. It is drawn to the same scale as the previous figures. The part sketched has been slightly calcined to reduce it to the same condition as the Oolitic specimens. A comparison of this figure with Fig. 2 shows that the divergence of this living Cheilostomatous *Escharoid* from the Oolitic *Diastoporidæ* is very slight. The punctation or perforation of the cœnœcium is coarser. The orifices are sunk, and the opercula have too little calcareous matter in their composition to retain their shape when burnt. The cells are shorter, but their narrow oblong shape is very visible when the surface is removed.

FIG. 8 represents a portion of the cœnœcium of a recent *D. patina*, Busk. It shows a striking difference in the character of the central decumbent cells and that of the protuberant cells, which generally rise from the margin of these cœnœcia. The punctation of the older opercula in this form is identical with that of the Oolitic forms figured above. The orifices in the decumbent cells are all elliptical and closed; those in the protuberant cells are round and open.

V.—NOTICE OF NEW FISH REMAINS FROM THE BLACKBAND IRONSTONE OF BOROUGH LEE NEAR EDINBURGH.

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

THE Blackband Ironstone, at present extensively wrought at Borough Lee, Dryden Vale, about 5½ miles to the south-east of Edinburgh, is a member of the Middle Division of the Carboniferous Limestone Series. It abounds in fish remains, most of them unfortunately in a fragmentary and scattered condition, nevertheless many of these are clearly new to science. Such of these new forms as are most distinctly marked I propose to notice in the present communication; the list will, however, doubtless be considerably extended by additional patient research, and we may also hope, that some further light will be thrown on the fishes, to which some of these fragments belonged.

The following is a list of the fish remains from this ironstone which have as yet come under my notice.

SELACHII.
Gyracanthus tuberculatus, Ag.
Tristichius arcuatus, Ag.
Ctenoptychius pectinatus, Ag.
Cladodus bicuspidatus, n.sp.
Cynopodius crenulatus, n.g. and sp.
Pleuracanthus elegans, n.sp.
Diplodus parvulus, n.sp.
Euctenius elegans. n.g. and sp.
DIPNOI.
Ctenodus angustulus, n.sp.
———, sp. indet.

GANOIDEI.
Acanthodes, sp.
Cœlacanthus striatus, n.sp.
Rhizodus Hibberti, Ag. sp.
Nematoptychius Greenockii, Ag. sp.
Elonichthys Robisoni, Ag. var.
Elonichthys, sp.
Gonatodus macrolepis, Traq.
Gonatodus, sp.
Ganopristodus splendens, n.g. and sp.

SELACHII.—*Cladodus bicuspidatus*, n.sp.

Usual length of tooth from $\frac{1}{8}$ to $\frac{1}{2}$ inch; a fragment shows that occasionally a larger size was attained. Base narrow, slightly reniform, gently convex behind, and slightly notched in front at the base of the principal cone. Principal or median cusp or cone varying much in slenderness, smooth, polished, acutely pointed, sharply carinated on both sides from its origin, more or less flexed backwards, and sometimes also inclined to one side; close to its origin in front a shallow concavity or groove appears passing into the notch on the anterior margin of the base. Sometimes only one cusp is present, more usually a single erect lateral denticle is found, about $\frac{1}{3}$ to $\frac{1}{2}$ the height of the median cusp, but in no instance is this balanced by one on the opposite side. In one case the two cusps are nearly exactly of the same size.

I have now upwards of thirty of these teeth before me, all of which display the same essential characters, though there is a wide range of variation as regards the slenderness, straightness, and relative size of the two cusps. Two specimens show each a cluster of teeth lying amid remains of the calcified cranial cartilage, and in one of these specimens, two teeth remain in their original relative position, one behind the other. It most nearly resembles *C. Pattersoni*, of Newberry, but may at once be distinguished by its two nearly parallel cones, of which the large one at least is trenchant to its origin. Regarding *C. Pattersoni*, Professor Newberry also states that "the teeth are placed in quincunx order instead of forming antero-posterior rows as in most of our sharks."

Cynopodius crenulatus, n.g. and sp.

Peculiar spoon-shaped bodies varying in length from half to one inch, and presenting a slender, straight, or slightly curved subcylindrical stalk, expanding at one extremity into a flattened, rounded, or obtusely hexagonal spatuliform piece. The spatuliform extremity is apparently covered with a thin layer of ganoine, which in one aspect (anterior) extends on to the stalk for about one-third to one-half its length, terminating behind in a point. Laterally and anteriorly the margins of this expanded portion are coarsely notched or crenulated, and from between the crenulations little grooves converge inwards over the surface towards the origin of the stalk. The stalk itself beyond the ganoid portion, which is very distinctly marked off, is rough and was evidently imbedded. The other side (posterior), rarely seen, is flatter, the spatuliform extremity is also marked with converging grooves, but the ganoid character of the surface scarcely extends on to the stalk. The stalk itself shows in different specimens considerable variations in its length, and also in its form, sometimes it is flattened on both aspects, sometimes obtusely carinated in front, and in most cases it shows a slight curvature, the convexity being anterior.

The microscopic structure strongly reminds us of *Ctenoptychius pectinatus*,—as in that form, in spite of the external appearance of a ganoid layer upon the free extremity, no such distinct layer is detectable in thin sections.

Whether these singular bodies are teeth, or dermal appendages, it is hard to say. At all events they seem to be selachian in their nature, and their resemblance to *Ctenoptychius pectinatus*, Ag., which Messrs. Hancock and Atthey considered as probably belonging to the latter category, is sufficiently obvious. The name *Cynopodius* is given in allusion to the manner in which the form of these bodies reminds us to some extent of the fore leg and paw of a dog.

Pleuracanthus elegans, n.sp.

Length of a perfect specimen $2\frac{1}{2}$ inches; straight, tapering, finely striated at the base, smooth and polished towards the extremity, a well-marked delicate groove running however along the whole length on each side close to the origin of the denticles. Denticles 26 on each side in two opposite rows, extending more than two-thirds the length of the spine, rather delicate, very oblique, with long flattened bases and ganoid rounded-conical tips.

The above described pretty little spine was lent to me by my friend Mr. Robert Kidston; and in my own collection are two others, of which one, nearly entire, would be originally of the same size, and corresponds closely in external characters, while the other is a fragment of a somewhat larger spine, and has the denticles somewhat more closely placed, or with relatively shorter bases.

Diplodus parvulus, n.sp.

Although there is no doubt that the teeth of *Pleuracanthus* were generally identical with those known as *Diplodus*, and although the common Coal-measure *Diplodus gibbosus* probably belonged to the same species as bore the spine known as *Pleuracanthus lævissimus*, nevertheless so long as these remains occur in so scattered a condition there must be insuperable difficulties as to accurately determining the spines and teeth which ought respectively to be classed together as belonging to the same species. Both generic names must therefore I fear continue to be used for some time to come, and as regards the *Diplodus* now to be described, though it may very possibly belong to the same fish as *Pleuracanthus elegans*, we have no evidence of the fact beyond their occurrence in the same beds. Height from base to apex of cusps $\frac{1}{8}$ to $\frac{3}{8}$ inch. Base rounded, thick and high in front, thin behind, concave below, with a knob or prominence at the anterior margin, and showing on the upper surface a rounded flattened boss behind the origin of the cusps. Anterior surface of base smooth, rounded, developing a more or less distinct carina, which ends above on a small boss or knob between the cusps; this knob being usually divided or notched into several minute rounded lobules, but there is no median cusp or denticle. Cusps two in number, strong, conical, diverging from each other, and also bent more or less backwards, carinated or trenchant on each side, and frequently showing towards their apices a few additional and fainter carinæ or ridges, both on their anterior and posterior surfaces. Very frequently one cusp is somewhat longer than the other.

This small *Diplodus* is easily distinguished from *D. gibbosus* by having between the cusps in front a small blunt lobulated boss, instead of a large pointed denticle. I have at present more than forty of these little teeth before me collected at different times, all of which agree in this prominent character, and differ only in trivial matters of detail, such as the relative prominence of the carina of the anterior surface, which indeed is sometimes obsolete.

Euctenius elegans, n.g. and sp.

Tooth (?) $\frac{1}{4}$ inch in length by $\frac{1}{8}$ in depth, somewhat elliptical in shape, convex on one surface, concave on the other, with one margin nearly straight, or with a slight sigmoidal curvature, the opposite margin evenly convex, one extremity rounded, the other narrowing to a point. The convex margin is divided in a comb-like manner into a series of closely placed acutely pointed denticles, fifteen to seventeen in number, and obliquely directed from the rounded towards the pointed extremity of the fossil. Counting from the former extremity, where they are very short, the denticles gradually increase in length to the thirteenth, which measures $\frac{1}{16}$ inch, whence they again diminish. Surface smooth.

Dipnoi.—*Ctenodus angustulus*, n.sp.

Palatopterygoid bone about $\frac{3}{16}$ inch in length, dental plate very narrow, bearing three, sometimes four, closely placed ridges, all passing forwards and slightly divergent or radiating from behind. Inner ridge longest, the succeeding ones becoming successively shorter; all are divided throughout their whole length into small bluntly pointed conical dental tubercles, and covered with a brilliant layer of ganoine. No mandibular teeth have occurred.

Of this minute and peculiar form of *Ctenodus* I have at present five specimens, all of nearly the same size. It is easily distinguished from any known species of

Ctenodus (as well as of *Dipterus*) by the narrowness of the palatal dental plate and the small number and slight divergence of the radiating denticulated ridges.

Another species of *Ctenodus* represented in my collection by a broken palatal tooth-plate of considerably larger size occurs also at Borough Lee. So far as the specimen goes, it shows some resemblance to *C. obliquus*, Hancock and Atthey, but it is too imperfect for accurate identification. Ribs, apparently of *Ctenodus*, are also not uncommon.

GANOIDEI.—*Cœlacanthus striatus*, n.sp.

Scales about $\frac{1}{4}$ inch in diameter, rounded, thin, inferiorly smooth, and showing externally a posterior free sculptured area, of about $\frac{1}{3}$ the extent of the whole surface. The ornament of this area consists of fine closely set rounded ridges sometimes bifurcating and intercalated, sub-parallel and slightly wavy, proceeding longitudinally to the posterior margin without convergence, indeed on the other hand sometimes diverging in their progress.

No remains of this species have occurred but the scales, which are, however, very distinct in their markings, the striæ of the free surface showing no tendency either to concentric arrangement or to convergence towards and round the middle line.

Ganopristodus splendens, n.g. and sp.

Fragments of flat dentigerous bones, varying in size from a few lines up to $1\frac{3}{4}$ inch in length and $\frac{1}{2}$ inch in depth. On one margin is a row of peculiar teeth, low, laterally flattened, anteriorly and posteriorly trenchant, confluent at the base with each other, and with the substance of the bone which carries them, and covered with a brilliant layer of ganoine, which extends along their bases, and is then thrown into delicate wavy folds—longitudinal in direction or sometimes forming little waves round the base of each tooth. Each tooth, moreover, besides its median bluntly conical point, has its anterior and posterior trenchant edges in most cases each serrated with a couple of secondary denticulations. In some instances the portion of bone which seems to have looked towards the cavity of the mouth, shows some small rounded tubercles or granulations.

These singular jaw-fragments form a complete puzzle, and though we may safely believe them to be piscine in their nature, I must confess that I have not the slightest idea of the fish to which they belonged. Unfortunately the number of specimens, which I have obtained, is as yet so few, that I have not been able to subject any of them to microscopic examination, but their external characters are so striking as to justify their receiving a name, and being placed provisionally among the Ganoidei.

REVIEWS.

I.—DER ÆTNA. NACH DEN MANUSCRIPTEN DES VERSTORBENEN DR. W. SARTORIUS VON WALTERSHAUSEN, V. DR. ARNOLD VON LASAULX. Ir. Band. Leipzig, 1880.

DR. A. VON LASAULX has undertaken the laborious, but grateful, task of publishing the observations left in manuscript of the Baron von Waltershausen, who died in 1876, and left behind a large mass of materials regarding the past history and present structure of Ætna, collected during no less than ten different visits made to Sicily between the years 1834—69. This labour of love could not have fallen into better hands; and in the volume before us, which is to be followed by another, we have an example of the highest act of friendship which a surviving friend and fellow-worker can perform for one who has passed away ere his own work has been completed.

In the volume before us, we have an account of Sartorius von Waltershausen's journeys to Sicily, the observations he was enabled to make on the volcanic region during many days devoted to his task, and these observations are accompanied by an exquisitely executed map on a scale of $\frac{1}{200000}$th, reduced from the larger chart constructed by Waltershausen himself. The work is also embellished by 14 large copper-plate engravings, giving striking views of Ætna, and its sections, besides numerous smaller woodcuts illustrating various topics connected with the subject. A portrait of Waltershausen forms an appropriate frontispiece to the volume. We feel sure that all students of Vulcanicity will welcome a work which, after Vesuvius, deals in an exhaustive manner with the most remarkable volcano in Europe.

Since the above was in type the second volume has come to hand—not less elaborate than the first. In this the authors deal with the geological structure of the region around Ætna, beginning with the old gneissose rocks which are the foundation for all the others, and then pass on to the consideration of those of Jurassic, Cretaceous, Tertiary and Quaternary age. The gradual unfolding of the volcanic history of the region, from the time of the oldest basalts which break through the Cretaceous beds, down to the most recent lavas, is described and illustrated by drawings, and maps. Chapters on the mineral products of Ætna form an appropriate conclusion to the volume. The map of the Valle del Bove on a scale of $\frac{1}{15000}$ is an admirable example of topographical portraiture. E. H.

II.—Dickens's Dictionary of the Thames. London, 1880. 16mo. pp. 268. Price 1*s*.

To this "unconventional handbook," Mr. Whitaker has contributed an essay on the Geology of the Valley of the Thames, which occupies a little over four pages of closely printed type. Dividing the area (for convenience of description) into three parts, he first gives an account of the formations exposed along the course of the river, and then points out the leading features in the geology of (1) the Upper Thames, to a little below Wallingford; (2) the Middle Thames, from near Wallingford to Richmond; and (3) of the Lower Thames, below Richmond. The influence of the geology on the scenery is noted by the way. Thus the several divisions of the Oolites, of the Cretaceous Series, of Older Tertiaries, Drift and Alluvium, are described. Only in connexion with the Drift of Glacial age do we meet with matters of dispute among geologists; but concerning this there is great variety of opinion, and some extensive patches of gravel in the area are left as of uncertain age. Speculations on the origin of the Boulder-clay are alluded to, but Mr. Whitaker contents himself with mentioning them without lending the weight of his own opinion to any particular explanation. The great deposits of brickearth and gravel which in the Lower Thames Valley, more particularly, have yielded so many remains of large mammalia, are classed as Post-Glacial, in the sense of their being newer than the Boulder-clay (usually known as the Chalky Boulder-clay), which is only found on the heights bordering the northern margin of the valley, and not in it.

As pointed out by Mr. Whitaker, these Post-Glacial beds constitute the most important division of the drift, as far as the Thames Valley is concerned, and he gives an interesting sketch of their method of formation. Concluding with some remarks on the origin of the Valley, he observes that it has been made by the slow, long-continued ceaseless action of the river, whose original course may in the first instance have been directed here and there by disturbances. Some signs of disturbance are pointed out as occurring near Wallingford, where the river cuts through the great Chalk range, and again from Greenwich to Erith a fault may have greatly aided the erosive action of the old river. We miss a reference to the view advocated by Prof. Ramsay of the original extension of the Chalk and the river cutting its way down before the escarpment was formed, this being the only plausible explanation of the breaching of the Chalk-range. Reference might also have been made to Phillips' "Geology of Oxford and the Valley of the Thames," and, without overstepping the bounds of modesty, to his own "Geology of the London Basin," as the two works dealing specially with the Geology of the area, and to which the anxious inquirer might go for further information.

III.—The Geological Survey.

THE attention of the public has recently been drawn to the state of the Geological Survey of the United Kingdom, by questions asked in both Houses of Parliament.

Thus, in the House of Commons on July 12th, Mr. Adam, replying to several members who urged the Government to do what they could to push on the Geological Survey, said that the Directors of the Survey had laid before him a plan by which he hoped it could be accelerated considerably, and completed in 1890. He added that if the House wanted the Survey to be pushed on more rapidly, they must vote more money. A few days afterwards, in replying to a question asked in the House of Lords, Earl Spencer was unable to state the exact date at which the Geological Survey could be finished. He observed, however, that it "would hold its own against that of any other country in the world," and that "one cause of the delay in the progress of the Survey was the advance which was being made in the science of geology."

These statements were preceded by the publication in the *Times* newspaper of a letter from an "Observer," who complained in bitter tones of the cost of the Survey, and at the time taken in its completion. The letter, however well-meant and disinterested, was calculated not merely to prove prejudicial to the Survey, but to the objects which the Survey is intended to serve. Had "Observer" taken the trouble to inquire into the reason of the facts which he pointed out, he must have been convinced that without interest and enthusiasm in their work, men would not be found to undertake the arduous duties of the Geological Survey at the extremely small rate of pay granted to them;[1] while if the Survey had been carried on

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[1] We are informed on good authority that some men who have served twelve years on the Geological Survey receive only £219 per annum; while attached to the Office either of the Geological Survey or of Mining Records is at least one who after serving over thirty years receives no larger sum; another who receives £180 after working for about twenty years; and a third who receives £175 after a term of fourteen years' servitude!

to its completion at the same rate at which it was commenced, its published works could not have held their own against those of any other country in the world. Under the circumstances it may be of some interest to sketch briefly the history of the Survey, and dispel the misapprehension that exists in some minds concerning its progress. At one time it was a customary thing for the President of the Geological Society to allude to the progress made by the Survey; but even the establishment is prone to hide its own light by not advertising its publications, and by not sending copies of them to journals, magazines, and newspapers for review.

As early as 1833, De la Beche had commenced to colour geologically some of the Ordnance Survey sheets of the south-west of England. Two years later, through his influence, an application was made by the Master General and Board of Ordnance for a government grant to combine a geological examination of the English counties with the Ordnance or Geographical Survey then in progress. At the request of this official, Buckland, Sedgwick, and Lyell drew up a joint report, in which they stated their "opinion as to the great advantages which must accrue from such an undertaking, not only as calculated to promote geological science, which would alone be a sufficient object, but also as a work of great practical utility."[1] Thus, early in the year 1835, the Geological Survey commenced its official existence, and De la Beche was chosen to organize and direct its operations. For some time it continued to form a branch of the Trigonometrical Survey of Great Britain, of which Colonel Colby was Superintendent, and in those days it was termed the "Ordnance Geological Survey." In 1845 its connexion with the Board of Ordnance ceased, and the Geological Survey was placed "under the Direction and Superintendence of the First Commissioner for the time being of Her Majesty's Woods, Forests, Land Revenues, Works, and Buildings." On the formation of the Department of Science and Art in 1854, the Geological Survey was "consigned to it, at first under the Board of Trade, and afterwards under the Committee of Privy Council on Education."[2]

An examination of the last issued catalogue of the Geological Survey Publications (1878) shows that while the whole of Wales and the greater part of England and Ireland have been completely mapped, much of Scotland yet remains to be done. Moreover, the survey of the Drift or "superficial" deposits, commenced about twelve years ago, is not very far advanced, so far as the published maps are concerned. In the earlier surveys these Drift deposits were entirely neglected, the so-called "solid" rocks only being laid down. Hence, any one acquainted with geological surveying would have been surprised had the work advanced more rapidly of late years, for some areas which on the old system might be mapped in a few months, would with the Drift Survey take as many years. The Drifts present problems as difficult to unravel as do any of the older rocks, while their varying position, their constant change of cha-

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[1] See Lyell's Address to Geol. Soc. 1836, Proc. Geol. Soc. vol. ii. p. 358.

[2] Jukes, Address at the Museum of Irish Industry, 1867.

racter, and the absence of palæontological guides, render their manifold divisions often much more difficult to trace out in the field. Nor should their importance be under-estimated, considering that they occupy more of the superficial extent of the country than any other group of beds, and in questions of water-supply and drainage, in matters relating to agriculture, road-metal, and brick-earth, they exercise as much, and in some cases more influence than do the older rocks.

Moreover, since the Geological Survey was commenced, the science of geology has grown very largely, and the rocks have been studied in much greater detail. Hence it is only to be expected that the work done thirty or forty years ago should require revision, and this chiefly in the form of addition. Fresh subdivisions of the strata have from time to time been made; some owing to the labours of the Geological Survey, others to the work of private individuals. As an instance of the former, the subdivisions of the Wealden Strata and Lower Greensand may be mentioned; and of the latter, the labours of Hicks on the older rocks of South Wales, of Hébert and Barrois on the Chalk, of Moore on the Rhætic Beds, of Allport, Bonney, and J. A. Phillips, on Eruptive Rocks. These labours serve to indicate the kind of new work that may necessitate revision of the older surveys.

In minute investigations, more especially in the collection of fossils from certain quarries or zones, the local or resident geologist must always possess great advantages over those whose attention is mainly given to tracing the rock-masses or groups of strata through large tracts of country.

With the accessions constantly made to our knowledge of each formation, the labours of the Geological Survey must ever be on the increase so long as the field-work lasts. And in addition to the preparation of maps and sections, each officer has the task of writing memoirs on the country surveyed, containing not only the information he has himself gathered in the field and obtained from well-sinkers, miners, and others, but all the facts which have been published on the geology of the district. Those acquainted with the literature of geology, of which the yearly "Geological Record" is an almost bewildering illustration, know that the task is no light one, and of course every year it becomes considerably greater.

Nor must it be forgotten that much of the field-work now-a-days is done on the maps of the scale of six inches to a mile, requiring far more minute observation than the one-inch surveys. Some of the maps not published on the larger scale are deposited in the Geological Survey Office for reference.

The importance of concentrating all the geological information is perhaps best exhibited in the publications referring to Coal-fields. There the evidence furnished by numerous mining operations is tabulated in section, to show the direction in which the various seams on the one hand increase in value and importance, or on the other hand deteriorate or thin away.

In the days of De la Beche, as "Observer" remarks, "the

Surveyors were not allowed to reside long in the same locality, but were kept actively moving to and fro," whereas now they often reside for a considerable time at one station.

Writing in 1861, Prof. A. Geikie says: "At present, the Surveyors work singly, each taking his own district, but at the period in the Survey's history to which reference is now made [1844], the geologists surveyed in parties of two or three, or even more. Sir Henry [De la Beche] used to be much with them, generally leaving London about the 1st of April. Hence, at little out-of-the-way villages, there would sometimes be collected half a dozen stalwart hammerers, who took up all the beds and devoured all the provisions the resources of the place could supply."[1] When so many worked one district, no wonder the ground was somewhat rapidly surveyed! Now that the men work singly, they naturally stay much longer, and with the advantage of railways (of little use in the earlier days of the Survey), it is of course possible for them to remain a considerable time at one station without detriment to the Survey, and considering the poorness of the pay, with less disadvantage to themselves. We have written thus much because "Observer" should have been more careful to write in a spirit of fairness to those who devote their lives to carry on the work of the Geological Survey.

In reading the Memoirs of Edward Forbes or of Jukes we may glean many interesting facts concerning life on the Survey. Knit together by a spirit of good-fellowship, the occasional meetings and consultations over difficult tracts of ground, and the enthusiasm with which the band of "Royal Hammerers" has carried its operations, under its able Directors, over hill and mountain, across moor and vale, seem to picture a life of thorough enjoyment. But it must be remembered that carried on year after year in all seasons, often isolated from friends and congenial society, and with no settled home, the Survey presents another aspect which for its success demands a love of the work, and needs a certain amount of sympathy from those interested in the science. What is to be the end of it all? is a question that naturally arises. In time of course the field-labours of the Survey must become restricted, but even "Observer" says, "The utter extinction of the Survey is not to be recommended, as it will always be desirable to retain a small staff of well-trained men to examine and record the results of future geological discoveries." Jukes thought that, "in addition to the Head Office in London, it will ultimately be found necessary to establish Local Geological Offices for each of the districts of the present Mining Inspectors, the Resident Geologist of the district working in combination with the Inspector in the collection and registration of all geological information, which may have either a scientific or practical value, and holding himself ready either to receive or impart geological information from or to all persons who may be interested in it."[2]

The importance of some such plan would be apparent to any one who would pass two or three days in the Office or Inquiry-room at

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[1] Memoir of Edward Forbes, pp. 377-378.

[2] Address at the Museum of Irish Industry, 1867.

Jermyn Street, where a number of individuals present themselves daily for the purpose of obtaining geological information. Among these are well-sinkers, stone-merchants, mine agents, colliery proprietors, landowners, parsons, medical officers and others, and all the knowledge possessed is invariably at the service of the seeker. A man may come with a bag of minerals and humbly desire their names, or he may bring somewhat furtively from his pocket a lump of iron-ore, saying not whence he obtained it, and ask whether it would pay for working. But apart from such comparatively trivial matters, information is more and more in request concerning good sources of water-supply throughout the kingdom, and the questions of drainage and health, upon which geology is calculated to throw so much light, must continue to engage public attention.

The service that may be rendered to individuals indirectly benefits the country at large. The money that has been wasted in fruitless trials for coal has been very great, and the Geological Survey has been instrumental in checking a large amount of such waste, while at the same time it has indicated many sources of future supply of mineral wealth. There is, however, no need to dwell upon the economic applications of geology, they are sufficiently well known if not always appreciated. Of these some striking illustrations are given by Professor Ramsay in his introductory lecture at the Government School of Mines in 1851.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 17, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.

The President called attention to the portrait of Dr. William Smith, presented to the Society by his grand-nephew, Mr. W. Smith, of Cheltenham, which was then suspended behind the chair, and expressed his great satisfaction at this most interesting picture being in possession of the Society. The portrait was painted by M. Forau in 1837. A hearty vote of thanks was passed for the same.

The following communications were read :—

1. "On Abnormal Geological Deposits in the Bristol District." By Charles Moore, Esq., F.G.S.

The author remarked that the Frome district shows numerous unconformable Secondary deposits and "vein-fissures" resting upon or passing down through the Carboniferous Limestone, as described in his former paper (Quart. Journ. Geol. Soc. vol. xxiii. p. 449). He gave some further particulars as to these deposits, and especially described the occurrence of Post-Pliocene, Liassic, and Rhætic deposits in the *Microlestes*-quarry near Shepton-Mallet. Here the lower part of a fissure is filled with a brown marl, containing crystals of carbonate of lime, and numerous remains of *Arvicolæ*, Frogs, Birds, and Fishes. The jaws of *Arvicola* were very abundant.

He then proceeded to describe the occurrence of similar phenomena in the Bristol area, as at Durdham and Clifton Downs, in the gorge of the Avon at Clifton, at Ashton and Westbury-on-Trym, in the slate rock, in Nettlebury quarry, at Clevedon, and on the Thornbury railway. He noticed the occurrence in the infillings of fissures traversing the Carboniferous Limestone of these localities of fossil remains belonging to various geological ages ; and he especially called attention to the presence in different deposits of an immense number of small tubular bodies of doubtful origin, for which, should they prove to be of organic nature, he proposed the name of *Tubutella ambigua.* By different authorities these little bodies have been assimilated to Serpulæ (*Filograna*), insect-tubes, and the casts of the fine roots of plants. With regard to the age of the fissure-deposits, the author remarked that although in some fissures the infilling shows a mixture of organisms, in most cases each "vein" appears to have an individuality of its own, and thus the veins represent intervals of geological time clearly distinct from one another, different fissures showing infillings of alluvium, Oolite, Lias, Rhætic, and Keuper beds. The presence of his *Tubutella* he considered to indicate freshwater conditions.

The author also referred to the discovery of *Thecodontosaurus* and *Palæosaurus* many years ago at the edge of Durdham Down, and discussed the age of the deposit containing them, which was originally supposed to be Permian, and was referred by Mr. Etheridge to the Dolomitic Conglomerate at the base of the Keuper. The author stated that he had found remains of the same genera in Rhætic deposits at Holwell and Clifton Down, and had hence been led to refer the two genera to that age. He stated, however, that he had since discovered teeth of *Thecodontosaurus* identical with those of the Bristol area in a deposit belonging to the middle of the Upper Keuper at Rushton near Taunton, and recognized certain differences between these teeth and those of the same genus from the Rhætic beds of Holwell; hence he was led to give up the notion that the former were of Rhætic age, and to refer them to the Upper Keuper; but he remarked upon the interesting fact that, while most of the generic forms of the Keuper are represented in the Rhætic, the species differ.

2. "Interglacial Deposits of West Cumberland and North Lancashire." By J. D. Kendall, Esq., C.E., F.G.S.

The glacial deposits of the district consist of an Upper and a Lower Boulder-clay, with an intercalated group of sand, gravel, and clay, the three being rarely present in one section. These deposits occur fairly continuously up to 500 feet above the sea, and in patches up to 1000 feet. Associated with these glacial beds are deposits of vegetable matter, which, when occurring on the sea-shore, have been designated submerged forests. The author considers this designation incorrect. The results of a large number of borings at Lindal, in Furness, are given, in which, beneath Upper Boulder-clay, one of these vegetable deposits was pierced, resting on Boulder-clays or sand. Similar deposits (which have been less completely examined) occur at Crossgates, Walney Island, and Drigg. Another is near St. Bees, which has been more minutely examined; and yet another near Maryport. These deposits are not, like the Lindal beds, clearly interglacial, but being compact and in other ways differing from the ordinary peaty deposits, are believed by the author to be so; further, they all rest on *Lower* Boulder-clay.

The author believes that the vegetable matter was not produced *in situ*, but accumulated under water. Rootstocks certainly occur in position of growth; but their roots do not pass down into the underlying Boulder-clay, so they may have floated into this position. The author considers this to throw light on the formation of coal.

II.—Dec. 1, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.

The following communications were read:—

1. "On Remains of a small Lizard from the Neocomian Rocks of the Island of Lesina, Dalmatia, preserved in the Geological Museum of the University of Vienna." By Prof. H. G. Seeley, F.R.S., F.G.S.

The author mentioned that Prof. Kornhuber had described, under the name of *Hydrosaurus lesinensis*, the remains of a Lizard from the Neocomian rocks of the island of Lesina, off the coast of Dalmatia. The University Museum at Vienna contains a slab from the locality, showing the hinder part of the skeleton of another Lizard, which had been lent to the author for the purpose of description by Prof. Suess. The specimen includes twelve dorsal and sixty-five caudal vertebræ, but the tail is incomplete. The sacral vertebræ are concealed, and the pelvis is imperfectly seen. Both hind limbs are fairly well preserved. The author described the distinctions which he considered to separate this animal from Kornhuber's species, consisting chiefly in the form and proportion of the dorsal vertebræ, which, instead of having the neural spine high and square, as in *Hydrosaurus*, have it depressed and produced both anteriorly and posteriorly; in the length and slenderness of the ilium; in the single-headed character of the ribs; and in the form and structure of the segments of the limbs, which appear to possess four tarsal and three metatarsal bones and five digits. The author proposed to name this Lizard *Adriosaurus Suessii.*

2. "On the Beds at Headon Hill and Colwell Bay in the Isle of Wight." By Messrs. H. Keeping and E. B. Tawney, M.A., F.G.S.

The authors criticized the views put forward by Prof. Judd in his paper published in the Q.J.G.S. vol. xxxvi. p. 13, and supported those established by the late E. Forbes and the publications of the Geological Survey. At the west end of the island, viz. at Totland and Colwell Bays, the authors stated that there is only one marine series, the Middle Headon, which they traced continuously through the cliffs—identifying it bed by bed at various points—the result entirely corroborating the sections of the Geological Survey. The section at the N.E. end of Headon Hill was described in detail, and Prof. Judd's interpretation of this part of the section analyzed. Prof. Judd places the marine Middle Headon at this point at the level of the sea, maintaining that 250 feet of beds (the altitude of the Bembridge limestone-quarry) intervene between the Bembridge limestone and the sea-level. The authors maintained that the top of the marine series is about 105 feet above the sea-level, that thickness of beds intercalated above the Middle Headon having no existence in fact, also that the Brockenhurst bed does not exist below the Bembridge quarry, where it is supposed to be (concealed by gravel) by Prof. Judd, and stated that there is no gravel at that spot to conceal anything, and that the beds which do exist there are the freshwater Osborne and Upper Headon beds as described by E. Forbes. They then adduced fossil evidence confirmatory of the stratigraphical; thus out of 57 species collected this summer at Colwell Bay, they found 53 at Headon Hill. (2) The sections at Whitecliff Bay and the New Forest (Brockenhurst) were next described. At Whitecliff Bay the 90 feet of beds which constitute the Middle Headon of the Survey section have been renamed "Brockenhurst series" by Prof. Judd; the authors maintained that the Brockenhurst bed, identical as to its fossils and position with that of the Whitley Ridge cutting, is represented by the lower 2 feet only, immediately above the freshwater Lower Headon. The Middle Headon at Whitecliff Bay contains lower zones than any developed in the Middle Headon of Headon Hill, for the Brockenhurst bed is entirely absent from the west of the island. The authors maintained that Prof. Judd has assigned a false position to this bed in his vertical section of New-Forest beds, and that instead of being higher than the Venus-bed horizon, it is plainly below it, since at Whitley Ridge it lies on the Lower Headon, being succeeded by the Venus-bed and then by the Upper Headon. The palæontological evidence was then discussed, and it was objected to Prof. Judd's lists that he has mixed up the Colwell Bay and Brockenhurst fossils in one list, thereby begging the question. In opposition to his statistics the authors maintained that the Brockenhurst bed has about 48 per cent. of species which pass up from the Barton beds, while the Venus-bed series of either Colwell Bay or Headon Hill have only 29 per cent., suggestive of the lower position of the former.

Further examination of the lists of fossils prepared from an examination of the Edwards collection shows that the Colwell-Bay and Headon-Hill marine beds have thirteen times more species common to themselves alone than either of them have in common with the Brockenhurst bed. The palæontological evidence is therefore in accord with the stratigraphical; they both occupy a higher zone than the Brockenhurst bed, which, when developed, occupies the base of the Middle Headon. The authors therefore reject Prof. Judd's term Brockenhurst series, and revert to the classification and nomenclature of the Geological Survey.

CORRESPONDENCE.

FOREIGN PEBBLES ON OUR SOUTH COAST.

Sir,—I am not aware if the significance of the foreign stones —I do not mean, of course, the granite blocks at Pagham, but smaller pebbles of granite, porphyry, etc., occasionally occurring in the shingle of our southern coasts—has ever been remarked upon; but it has occurred to me, as no doubt to a hundred other geologists, both professional and amateur, that these are almost the only actual evidence that can be expected, in the absence of Drift and ice-markings, in favour of Dr. Croll's suggestion as to the passage of a great ice-sheet over the South-Eastern corner of England during the height of the Glacial Epoch. I have frequently observed such stones both here and at Brighton, and only within the last few days, I have picked up a variety of granites, syenites, quartz-pebbles, and porphyries (two or three dozen in all), some red sandstones, and one peculiar siliceous *greenstone*, the original source of which might possibly be identified. It is very improbable that any of them are British, much more likely that they are Scandinavian. Possibly, of course, they may be parts of ballast, but I confess it seems to me much more probable that they are portions of Scandinavian drift. The evidence is slight, but it seems the only kind obtainable, and it may be taken for what it is worth.

The mass of the beach along our south-eastern coasts, of course, consists of Chalk flints, but even these are of a very varied character, the majority being unaltered and referable at once to the original Chalk, while others bear marks of having once belonged to Eocene pebble beds (London Clay basement, Oldhaven or Bagshot), a few to the Isle of Thanet Sands, and a very large proportion, as I infer from their brown coatings and sub-angular forms, to glacial gravels or drift. J. A. Birds.

St. Leonards-on-Sea, *Oct.* 16, 1880.

ON THE DISTRIBUTION OF VOLCANOS.

Sir,—Having been absent during the last summer in the north part of Yezo and the Kurile Islands, it was not until a few days ago that I received your Number of May, 1880, in which there is a criticism of a short paper of mine on the "Geographical Distribution of Volcanos," published by you in April, 1880.

This paper was chiefly written for the purpose of pointing out a fact, which, so far as I am aware, had not previously been noticed, namely, volcanos are chiefly distributed along the borders of land which slopes STEEPLY beneath the sea.

Whilst suggesting an explanation for this I had reason to refer to the position of an isothermal surface lying partly under the land and partly under the sea. I then said that it was not unlikely that this surface would be found at a "much greater depth beneath the rocks which form the bed of the ocean," than the depth at which we should find it beneath the land.

The Rev. O. Fisher pointed out to me that the greater depth could hardly be qualified by the word "much," and with his reasoning I for the most part agree.

I should, however, like to point out that the difference in temperature beneath the land and sea has by him, I think, been somewhat under-estimated. He takes the mean temperature of England as being 50° F., whilst that of the sea-bottom is 32°.

If we remember that the greater number of active volcanic bands lie within or near the tropics, we shall be compelled to take the land temperature at something above 50° F.

In Tokio, as recorded at the Yamato Yashiki Observatory, the mean temperature at a depth of 10 ft. is about 60° F. Farther south it will probably be much greater. This will make the solid crust beneath the sea more nearly 2000 than 1000 ft. thicker than that beneath the land, and this as a fractional part of the zone above rocks at the melting temperature I regard as a considerable amount. Even accepting Mr. Fisher's estimate of 900 to 1080 feet, the reason I have advanced for the peculiar position of volcanos will, I think, still hold good, if not for the whole of the phenomena, at least for a considerable portion of it. John Milne.

Imperial College of Engineering, Tokio,
Japan, *October* 10*th*, 1880.

ON THE OLD RED SANDSTONE OF THE NORTH OF IRELAND.

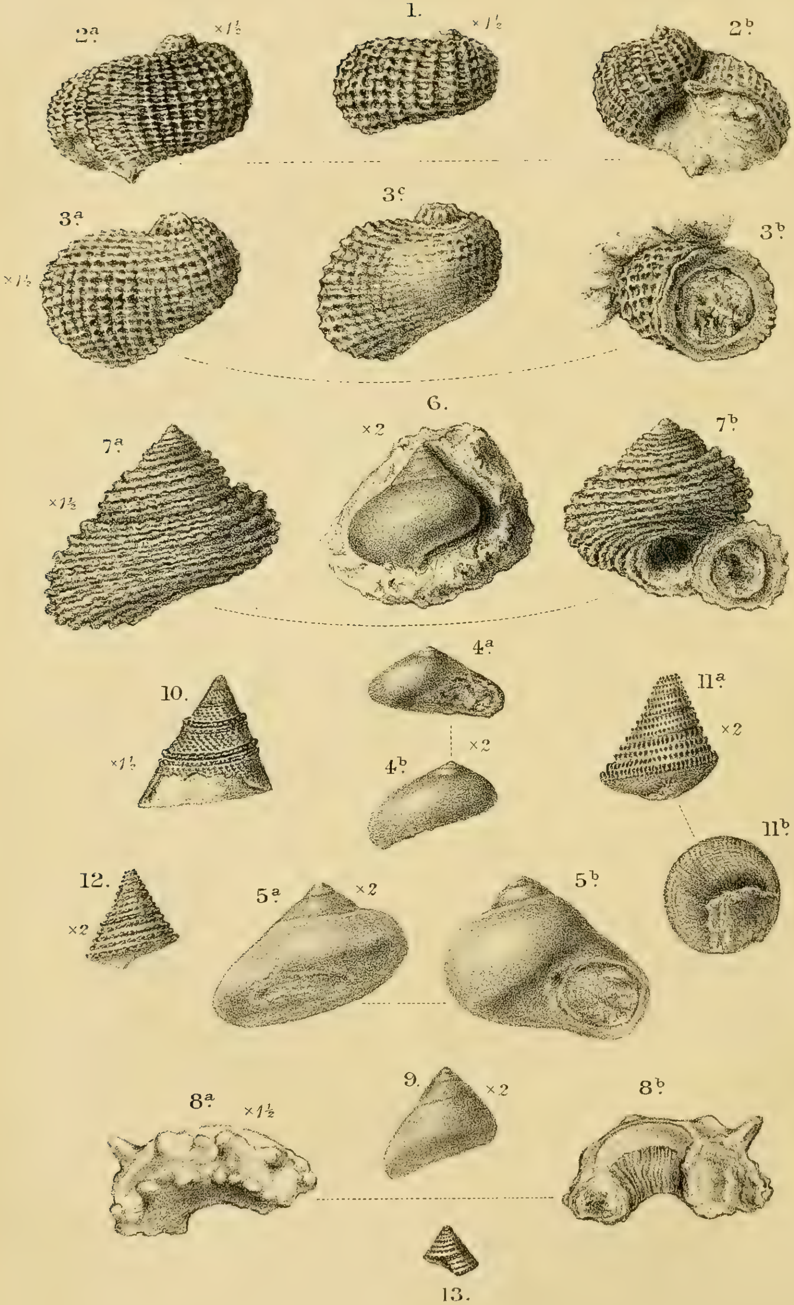
Sir,—In the November Number of the Geol. Mag. Mr. Kinahan makes some remarks on a paper of mine bearing the above title, to which I beg to make the following reply.

I am at a loss to know how Mr. Kinahan learns from the Survey Map that the Old Red Sandstone at any place "graduates" into the "fossiliferous Pomeroy Rocks." No fact is more clearly shown on that map than that these widely different formations are unconformable. The conglomerate in the townland of Aghafad I believe to be of Lower Silurian age.

I do not deny that there *may* be representatives of the Kiltorcan beds in the North of Ireland, although I have not hitherto recognized them, believing, for the reasons stated in my paper, that the "Yellow Sandstones" of that district, characterized by the occurrence of *Modiola McAdami* and other marine fossils, are far more probably on the horizon of the Calciferous Sandstone of Scotland, and the Carboniferous Slate and Coomhola grit of the South of Ireland. As to the position of these latter groups, I beg to refer Mr. Kinahan to Jukes's Manual of Geology, where he will find them placed as I have done—at the base of the Carboniferous Limestone, and correlated with the Calciferous Sandstone.

The word "Upper" prefixed to "Old Red Sandstone of Waterford" is simply a mistake in the abstract of my paper, which does not occur in the original. J. Nolan.

47, Great James Street, Londonderry,
November, 1880.



A. S. Foord. del. et lith. Mintern Bro's, imp.

Corallian Gasteropoda. Yorkshire.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VIII.

No. II.—FEBRUARY, 1881.

ORIGINAL ARTICLES.

I.—Contributions to the Palæontology of the Yorkshire Oolites.[1]

Part VI.

By Wilfrid H. Hudleston, M.A., F.G.S., V.P.G.A.

(PLATE III.)

Genus Nerita, Linnæus, 1758. Subgenus Neritopsis, Grateloup, 1832.

There is no positive evidence that any species of *Nerita* has been found in the Corallian Rocks of Yorkshire. It is true that *Nerita lævigata*, Sow., is quoted by Phillips (G. Y. 1875, p. 258), but this fossil is well known to be a *Monodonta*, and it is doubtful if the exact form occurs on this horizon (see postea, *Turbo Erinus*). The same author also quotes "*Nerita bullata*" as occurring in the Coralline Oolite. I can find no reference to this species, and am at a loss to understand what fossil is intended to be thus designated. There are casts in the Coral Rag of North Grimston which may belong to a species of *Nerita*.

The subgenus *Neritopsis* is probably more thoroughly marine. D'Orbigny (T. J. ii. p. 221) refers to twenty-three fossil species, and regards the maximum of its development as having occurred in the Corallian stage. It is, however, an important Tertiary group.[2] Specimens belonging to three species of *Neritopsis* have been found sparingly in the Coral Rag of Yorkshire: of these *N. Guerrei*, Héb. and Desl., has been noted before, and although not frequent is the least rare of the three.

36. Neritopsis Guerrei, Hébert & Deslongchamps, 1860. Plate III. Figs. 3*a*, *b*, *c*.

Neritopsis Guerrei, Hébert & Deslongchamps, 1860, Bull. Soc. Linn. Norm. vol. v. p. 185, pl. i. figs. 4*a*, *b*, *c*, *d*.

Bibliography, etc.—The diagnosis of this Callovian species by the authors is sufficiently loose, and the three specimens figured by them embrace a considerable width of variation. The ornaments in their fig. 4*c* have the most resemblance to our Corallian shell. On the whole the resemblance is sufficiently near to justify the identification in preference to making a new species. The authors

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[1] Continued from the December, 1880, Number, p. 538.

[2] Cf. Dr. Woodward, in Geol. Mag. for 1879, p. 545.

observe that their species is near to *N. Moreauana,* D'Orb., and *N. Cottaldina,* D'Orb., from the Coral Rag.

Description.—Specimen from the Coral Rag—probably of Seamer or Ayton (Strickland Collection). Figs. 3*a*, *b*, x $1\frac{1}{2}$.

Length	16·5 millimètres.
Width	18·7 ,,
Length of last whorl	13· ,,

Shell transversely ovate oblong. Spire short, formed of about three whorls, of which the last is immense in comparison with the rest of the spire. The whorls are widely separated: the body-whorl is flatted posteriorly, so that the shell is tumid angular rather than convex. The ornaments consist of a series of moderately strong transverse ribs, of which three or four towards the centre are somewhat more prominent: the longitudinal ribbing is less strongly indicated. The nodes at the intersections were probably spiny, and the whole pattern is coarse and irregular.

The aperture is wide and circular, with a thick peristome, the edge of which is crenulated, except upon the inside, where the lip is smooth and prominent.[1]

Another specimen (Leckenby Collection), Fig. 3*c*, natural size.

Length	22 millimètres.
Width	25 ,,
Length of last whorl	18 ,,

This is a much larger specimen than the one previously described, but the proportions are nearly the same. The shell has suffered from wear, but enough character remains in the angular outline of the upper part of the body-whorl, and the irregularity of the transverse ribbing, to warrant the identification.

Relations and Distribution.—This somewhat average form is doubtless related to the two species next described, though it clearly differs from either, both in contour and character of ornament. Perhaps the nearest Corallian form described from the French beds is *N. Cottaldina,* D'Orb. (Terr. Jurass. vol. ii. p. 227, pl. 301, figs. 11—13), but that species is smaller.

N. Guerrei, as identified, occurs principally in the Coral Rag of the Scarborough district (Seamer, Ayton, Brompton), where Oxfordian forms would seem to have lingered more than on the south side of the Vale of Pickering. It has been quoted from Upware possibly in mistake for *N. decussata,* and is mentioned by Whiteaves in the Oxford list.

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[1] As one of the characteristic features of *Neritopsis* is held to be the notch at the columellar lip, it might be objected that, in the case of this specimen, no such notch is shown. A similar objection may be urged in the case of all D'Orbigny's figures in the Terrains Jurassiques. Two reasons may be adduced for this. *Firstly,* the columellar notch may not have been so strong in the Secondary as in the Tertiary species. *Secondly.* it is quite certain that the presence of a hard matrix tends to obscure what should be the characteristic feature, and more complete development, where safe, might reveal the existence of the notch. In the very well preserved Tesson Collection, now in the New Natural History Museum, there is only one specimen of *Neritopsis* where the notch is visible. In this case the anterior portions of the inner lip are decayed away, but, as the aperture happens to be quite clear of matrix, we are able to see the entire cavity.

37.—Neritopsis Moreauana, D'Orbigny, 1847. Plate III. Figs. 2*a*, *b*.

Neritopsis Moreauana, D'Orbigny, 1847, Prod. de Pal. Stat. vol. ii. p. 7.
Idem. 1852, Terr. Jurass. vol. ii. p. 226, pl. 301, figs. 5—7.

Bibliography, etc.—The original specimen was from the Corallian of St.-Mihiel. We have already seen that Hébert and Deslongchamps noted its relation to the foregoing species.

Description.—Specimen from the Corallian of Yorkshire (Strickland Collection). The outer lip is too much broken away for accurate measurement. Shell transversely oval. Spire very short and very open, formed of two to three convex whorls which are wide apart. Body-whorl immense in proportion, and rather rounded off at either extreme, so as to give a truly convex character to the shell. The ornaments consist of a double series of ribs closely set and granulated at the nodes. In the transverse series of ribs there is a slight tendency to unequal alternations. The longitudinal system is somewhat the most prominent, and this feature is especially noticeable in the penultimate whorl, where the intercostal spaces are finely striated.

The outer lip and anterior extremity of the shell are imperfect.

Relations and Distribution.—Although the specimen in question may not exactly correspond with the one originally described by D'Orbigny, the differences would not warrant the making of a new species. It obviously differs from Yorkshire specimens of *N. Guerrei* in the general convexity of the whorl, in the fine and regular ornamentation, and in the nodular character of the intersections. The form would seem to be rare, as few authors allude to *N. Moreauana.*

As far as I know, Sir Charles Strickland's specimen is the only one which has ever been found in Yorkshire.

38.—Neritopsis decussata, Münster, 1844. Plate III. Fig. 1.

Natica decussata, Münst., 1844, Goldfuss, pt. 3, p. 111, pl. 199, fig. 10.
Neritopsis decussata, D'Orbigny, 1847, Prod. de Pal. Strat. vol. ii. p. 7.
Idem, D'Orbigny, 1852, Terr. Jurass. vol. ii. p. 227, pl. 301, figs. 8–10.
Neritopsis corallensis, Buvignier, 1852, Stat. Géol. de la Meuse, p. 31, pl. 22, figs. 38—40.

Bibliography, etc.—Münster's shell was from the Corallenkalke of Nattheim in Wurtemberg. It has been identified by D'Orbigny with a species of *Neritopsis* occurring in the Corallian of St.-Mihiel, and if we may judge from the figure in Goldfuss the identification is fairly warranted. I cannot see any difference between Münster's species, as identified by D'Orbigny, and *N. corallensis*, Buvignier, from the Coralline Oolite of St.-Mihiel. Still Buvignier may not have been satisfied with D'Orbigny's identification. There can be little doubt that the Yorkshire shell under consideration answers to the figures and description in the Terrains Jurassiques, and is the shell identified in the Prodrome, whether the original identification by D'Orbigny be correct or not.

Description.—Specimen from the Coral Rag of North Grimston (Strickland Collection).

Total length	12·5	millimètres.
Width	14·25	,,
Length of last whorl	11·0	,,

Shell transversely oval oblong. Spire extremely short, and formed of two to three whorls, of which the last is immensely larger every way than the others. Body-whorl flattish posteriorly, affording an angular rather than a convex outline. Ornaments strongly sculptured and of great regularity. About twelve stout transverse ribs are met at right angles by a system of longitudinal ribbing somewhat less prominent. The points of intersection are marked by thick tuberculations, the intervening meshes being regular oblongs of considerable depth.

The anterior portion of the body-whorl and the aperture are too much concealed in matrix for accurate description.

Relations and Distribution.—The points of resemblance in this well-marked species to the two previously described are, in a great measure, those common to the genus. The contour and ornamentation separate it clearly from *N. Moreauana*, and although it has stronger affinities with the form referred to *N. Guerrei*, yet the regularity and nearly uniform strength of the ribbing is a good character which may be relied upon in instituting a comparison with that species.

N. decussata is very rare in Yorkshire, not more than two specimens at the utmost having come under my notice. A larger variety, which may probably be referred to this species, occurs in the Coral Rag of Upware, which has so many fossils in common with the North Grimston Rag. The same species has also been found in the Coral Rag of Wiltshire. Buvignier states that *N. corallensis* (believed to be a synonym) is rare in the Corallian of the Meuse.

No species of *Neritopsis* in any way resembling either of the three described is quoted from this horizon in North Germany. Nor have any of them been noticed at Boulogne or at Weymouth. A large development of actual Coral seems to have been favourable to this section of the genus.

Genus Turbo, Linnæus, 1758.

This genus was the exhaustive division in which numbers of Jurassic shells were put as a sort of temporary resting-place. After the removal of the section of *Littorina* previously described, the species remaining are neither numerous nor important as contributing to swell the shell-beds of the Corallian rocks in Yorkshire. Under this general heading we may for present purposes include *Crossostoma*, Lycett, 1850, *Monodonta*, Lamarck, 1801, and *Delphinula*, Lamarck.

39.—Turbo (Crossostoma) corallensis, Buvignier, 1852.

Plate III. Figs. 4*a*, *b*.

Turbo corallensis, Buvignier, 1852. Stat. géol. de la Meuse, p. 37, pl. 24, figs. 21, 22.

Description.—Specimen from the Coral Rag of Ayton (my Collection).

Length	6·5 millimètres.
Width	10 ,,

Shell subglobular, smooth. Spire composed of about three whorls, scarcely separated by any suture. The last whorl is enormously larger than the preceding ones. Base convex and solid. Aperture imperfectly preserved.

Relations and Distribution.—The very great width of this shell in proportion to its height, the flattening of the spire, and obsolete character of the suture, whereby the entire shell seems almost to consist of one whorl, serve to distinguish this species. On the Continent no one but Buvignier records its presence, unless it is concealed under some synonym. It is however closely allied to *Crossostoma discoideum*, Morris and Lycett (Great Ool. Moll. p. 73, pl. xi. fig. 7), and something very like it turns up on several horizons in the Jurassic rocks.

The dimensions of the specimen figured exceed those given by Buvignier, but the proportions are about the same. Rare in the Coral Rag of Ayton and neighbourhood.

40.—TURBO (MONODONTA) ERINUS, D'Orbigny, 1847. Plate III. Figs. *5a*, *b*.

Turbo Erinus, D'Orbigny, 1847, Prod. de Pal. Strat. vol. ii. p. 9.
Turbo inornatus, Buvignier, 1852, Stat. géol. de la Meuse, p. 37, pl. 26, figs. 27 and 28.
Turbo Erinus, D'Orbigny, 1852, Terr. Jurass. vol. ii. p. 362, pl. 336, figs. 12–14.

Bibliography, etc.—It would be a difficult and thankless task to go closely into the history of this very average form. In the Prodrome, D'Orbigny describes a species of *Turbo* from the Corallian of St.-Mihiel as "wider than high, entirely smooth, whorls slightly swollen, mouth round." In the Terrains Jurassiques, the same author gives the following dimensions for this shell, viz. length 11 mm., width 13 mm., spiral angle 90°. He regards the *Turbo lævis*[1] of Buvignier (*op. cit.* p. 37, pl. 26, figs. 29, 30) as being the same, but this is a much higher shell, having a spiral angle of lower value. There can be very little doubt that the Yorkshire specimen described below is the *Turbo inornatus* of Buvignier, but as the description in the Prodrome, as far as it goes, is applicable, D'Orbigny's name (*Erinus*) would seem entitled to priority, though otherwise I should have preferred to adopt Buvignier's name.

Description.—Specimen from the Coral Rag of North Grimston (Strickland Collection).

Length	12 millimètres.
Width	13·5 ,,
Spiral angle	94°.

Shell subglobular, wider than high. Spire composed of about five whorls, which are smooth, convex, and fairly marked off by the

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[1] Since D'Orbigny (*op. cit.* p. 362) quotes from the Statistique géologique de la Meuse, it is clear that the date, 1850, prefixed to vol. ii. of the Terrains Jurassiques is incorrect.

suture. The body-whorl is greatly larger than the rest of the spire, and has the posterior area slightly flatted. Base solid and rather tumid. The aperture is oblique, and not sufficiently well preserved to show the indentation on the columella.

Relations and Distribution.—This may be deemed one of the representatives on a higher horizon of *Monodonta* (*Nerita*) *lævigata*, Sow. (Min. Conch. pl. 217, fig. 1), which was originally described from the Inferior Oolite of Dundry. Except that this latter shell is slightly more Neritoid, and not quite so wide, the differences are not very great. Doubtless such a form, with modifications, might be expected to run throughout the Jurassic rocks. In Yorkshire this particular form is rare.

41.—Turbo lævis, Buvignier, 1852. Pl. III. Fig. 6.

Turbo lævis, Buvignier, 1852, Statis. géol. de la Meuse, p. 37, pl. 26, figs. 29, 30.

Bibliography, etc.—We have already seen that *Turbo lævis*, Buv., was regarded by D'Orbigny as being identical with his *Turbo Erinus*, but the proportions do not correspond. Buvignier's *T. lævis* comes very near to *Monodonta papilla*, Héb. & Desl. (Bull. Soc. Linn. Norm. tome v. p. 211, pl. iii. fig. 1), which fossil is recognized by De Loriol and Pellat (Jurass. Supr. vol. i. p. 121, pl. ix. figs. 23, 24) as occurring in the "Séquanien" of Boulogne.

Description.—Specimen from the Coral Rag of Hildenley (Strickland Collection).

Length	9 millimètres.
Width	9 ,,
Spiral angle	75°.

Shell subconical, globular, equally wide as high. The spire consists of about five whorls, smooth, convex, and distinctly separated by a suture. Body-whorl very large, globose, with a slight tendency to flattening of the posterior area. Base tumid. Aperture involved in matrix.

Relations and Distribution.—The proportions of this unornamented *Turbo* separate it from the species last described, with which, however, it may be deemed to share affinities in the original *Monodonta* (*Nerita*) *lævigata*, Sowerby. Buvignier's type of *T. lævis* is only two-thirds the size of the Yorkshire specimen now figured, but the proportions correspond exactly. It is stated to be common in the White Oolite of the Coral Rag of St.-Mihiel.

In Yorkshire *Turbo lævis* is sparingly distributed throughout the Coral Rag, and is, perhaps, the most usual of the three unornamented forms of *Turbo*, which have hitherto been lumped under the general designation of *Nerita lævigata*.

42.—Turbo (Delphinula) funiculatus, Phillips, 1829. Plate III. Figs. 7*a*, *b*.

Turbo funiculatus, Phillips, 1829, Geology of Yorkshire, vol. i. pl. iv. fig. 11.
Delphinula muricata, Buvignier, 1843, Mem. Soc. Verd. p. 243, pl. iv. figs. 31, 32.
Idem. Idem. 1852, Stat. géol. de la Meuse, p. 35, pl. 32, figs. 19-21.
? *Delphinula muricata*, Buv. De Loriol & Pellat, 1874, Jurass. Supr. de Boulogne, p. 113, pl. ix. figs. 30-33.
Littorina funiculata, Phillips, 1875, G. Y. 3rd edition, pp. 258, 325.

Bibliography, etc.—It is so rare to find a good specimen of this not very common fossil, that Phillips may be forgiven for his imperfect figure, whilst no blame can attach to Buvignier for not having recognized Phillips' species. Indeed, there may be differences between the Yorkshire shell and that of the Meuse (magnified doubtless in figures), which would induce some to separate them specifically. Buvignier's description tallies better than any of his figures. The shells figured by De Loriol from the Séquanien of Boulogne may belong to this species. At the same time that author exercises a wise discretion in hesitating to connect his shells with the *Turbo muricatus* of Sowerby, seeing that this very abundant fossil has nothing in common with the genus *Delphinula*. The following extract from Buvignier (Stat. géol. de la Meuse, p. 35) bears upon this subject:

"M. d'Orbigny, qui n'admet pas de Littorines dans les terrains jurassiques, a probablement confondu cette espèce avec le *Littorina muricoides*, Desh., qu'on trouve dans le même gissement, mais qui n'a ni la bouche entière et circulaire, ni les tours disjoints qui font du *D. muricata* une des Dauphinules les mieux caractérisés."

Description.—Specimen from the Coral Rag of Brompton (Strickland Collection).

Length	23 millimètres.
Width....................................	21 ,,
Spiral angle	75°.

Shell turbinated, nearly as wide as long, umbilicated. The spire consists of about five whorls, which increase regularly and rapidly, and are very open, and separated by a broad suture. They are ornamented with very coarse scaly ribs arranged transversely; on the penultimate these are five in number. Some of the ribs towards the posterior part of the body-whorl are strongly muricated. The ribbing is continued of almost equal strength throughout the base of the shell, and the umbilicus is bordered by a band with rather stronger serrations. The aperture is perfectly circular, with a very thick peristome, which is free and with crenulated edges. Umbilicus well marked.

Relations and Distribution.—Sir Charles Strickland's shell, besides being in a better state of preservation, is larger than an average of Yorkshire specimens, which also vary slightly in ratio of length to width, and seldom have so deep an umbilicus. The relations of this species to other members of the genus *Delphinula* are not very clear at present, and it would be difficult to point out its representatives in the English Jurassic rocks. Buvignier describes *D. muricata* as rare in the "Oolithe ferrugineuse" above the Oxford Clay. In Yorkshire the corresponding form occurs chiefly in the Coral Rag of the Scarborough district, and in the base of the Coralline Oolite at Pickering. I am not aware that it has been noted in other parts of England.

43.—Turbo (Delphinula) Pellati, De Loriol, 1874. Plate III. Figs. 8*a*, *b*.

Delphinula Pellati, De Loriol, 1874, De Loriol & Pellat, Jurass. Supr. de Boulogne, p. 115, pl. ix. figs. 34 and 36.

Description.—Fragment from the Coral Rag of Langton Wold (my Collection).

The external portion of the whorl is strongly bicarinated, and widely umbilicated. The keels carry thick spinous projections, those of the posterior keel being the strongest; the intermediate space between the two keels is excavated. The base of the last whorl is penetrated by a great umbilicus, funnel-shaped and bounded by a smooth belt, below which the sides of the excavation are marked by fine striæ of growth.

Relations and Distribution.—This fragment so well fits the very complete description given by De Loriol that there can be little doubt as to the identification. The original specimens were obtained from the Séquanien of Boulogne. Although Buvignier has described and figured some half dozen species of *Delphinula* from the Corallian of the Meuse, none exactly fit this one. Since the Boulogne beds have not, as a whole, any strong affinity with the Corallian of Yorkshire, this identification forms an interesting exception. The Yorkshire specimen is at present unique; it was found in one of the quarries on Langton Wold, where so many curious fossils have been discovered. It may be looked for in the Coral Rag of Upware.

Genus Trochus, Linnæus, 1758.

This genus is but poorly represented in the Corallian rocks of Yorkshire. The species are small in size and few in number; yet even these have been overlooked, since Phillips, in his last edition, does not enumerate a single *Trochus*. On the other hand, Buvignier has described about fifteen species from the Coral Rag of the Meuse, of which two or perhaps three may be approximately identified in our beds, whilst one or two species have not at present been noted elsewhere.

44—Trochus obsoletus, Rœmer, 1836. Plate III. Fig. 9.

Trochus obsoletus, Rœmer, 1836, Ool. Geb. p. 151, pl. xi. fig. 5.
Trochus inornatus, Buvignier, 1852, Stat. géol. de la Meuse, p. 37, pl. 26, figs. 23, and 24.

Description. — Specimen from the Passage-beds in the Lower Limestones at Wydale (my Collection).

Length	7·5 millimètres.
Width	8· ,,
Spiral angle	75°.

Shell conical, slightly oblique, not umbilicated. Whorls four or five in number, very regular, smooth and nearly flat, suture but slightly accentuated. Aperture broken away.

Relations and Distribution.—An average form, which probably occurs with slight modifications on several horizons. Buvignier's specimens, which are rather larger, occur rarely in the ferruginous

Oolite of Viel St.-Remy. Quoted by De Loriol from the Séquanien of Boulogne. The Yorkshire specimen is one of the very few Univalves of the Lower Limestones, which are Oxfordian rather than Corallian. Most of the Univalves in these beds are rather dwarfed.

45.—Trochus acuticarina, Buvignier, 1852. Plate III. Fig. 10.

Trochus acuticarina, Buvignier, 1852, Stat. géol. de la Meuse, p. 38, pl. 25, figs. 31 and 32.

Description.—Specimen from the Coral Rag of Yorkshire, probably from the Howardian Hills (Leckenby Collection).

Length	15 millimètres.
Width	13 ,,
Spiral angle	56°.

Shell conical, trochiform, but slightly oblique. Spire composed of five or six whorls, which increase with great regularity and without convexity. The posterior whorls of the specimen are so far injured, that no detailed description can be given; the same remark applies to the base of the shell. Of those portions preserved, a most characteristic feature is a very prominent keel at the base of each whorl; this keel was probably serrated, but not deeply. Below the keel the suture is not very strongly defined, but there is a granulated line at the top of the succeeding whorl, followed by faint transverse lines, which are slightly decussated by fine longitudinal lines sloping from left to right. Thus the character of the whorl may be described as flat with very shallow sculpture, suddenly curving upwards at the base into a very prominent keel.

Relations and Distribution.—The specimen in the Leckenby Collection is the only one known to have been found in Yorkshire. It answers fairly to Buvignier's description of *T. acuticarina*, though it must be admitted that the figures in the Stat. géol. de la Meuse are not very like the one in the accompanying Plate (III. Fig. 10). But the Yorkshire specimen is very imperfect and much involved in matrix. Buvignier's species is said to be common in the Coral Rag of the Meuse; it is not quoted from the Séquanien of Boulogne nor by Brauns as occurring in North Germany.

46.—Trochus granularis, sp.n. Plate III. Figs. 11*a*, *b*.

Description.—Specimen from the Corallian of Yorkshire (Leckenby Collection).

Length	8 millimètres.
Width	8 ,,
Spiral angle	64°.

Shell conical, trochiform, nearly equilateral. Spire composed of few whorls, which are perfectly flat, scarcely separated by suture, and increase with great regularity. The ornaments consist of a number of close-set transverse costæ, which are conspicuously granulated, the granulations being small, round and very equal. The body-whorl has four rows of such granulated costæ, of which the lowest one is the most conspicuous, and is slightly grooved anteriorly. This forms a prominent margin for the base of the shell, which is nearly flat and marked by fine spiral lines, which decussate with equally fine lines of growth. No umbilicus: aperture involved in matrix.

Relations and Distribution.—In ornamentation this very pretty species approaches *Trochus echinatulus*, Buvig. (*op. cit.* p. 38, pl. 26, figs. 7 and 8), from the Upper Coral Rag of Dun, but Buvignier's is a more elongated form. The Yorkshire specimen is unique at present.

47.—Trochus Aytónensis, Blake and Hudleston, 1877. Plate III. Fig. 12.

Trochus Aytonensis, Blake and Hudleston, 1877, Quart. Journ. Geol. Soc. vol. xxiii. p. 365, pl. xiv. fig. 1*d*.

Description.—Specimen from the small shell-bed in the base of the Coralline Oolite at Pickering (Leckenby Collection).

Length	6	millimètres.
Width	5·5	,,
Spiral angle	60°.	

Shell conical, trochiform, not umbilicated. Spire composed of whorls which are flat, increase with great regularity, and are scarcely separated by the suture. Each whorl is ornamented with a nodular band at the base, and three rows of tubercles above. These tubercles are large, well cut, and drawn out transversely, so that each tubercle is oval rather than circular. The band at the base of the body-whorl forms a conspicuous prominence, and is worn nearly smooth. Base nearly flat; no ornaments visible.

Relations and Distribution.—From the previously described species the difference in the ornamentation clearly separates it. *T. Aytonensis* has affinities with *T. echinatulus*, Buv., and also with *T. carinellaris*, Buv. (*op. cit.* p. 39, pl. 27, figs. 10 and 11). The type specimen, described by Blake and Hudleston, is from the Coral Rag of Ayton. Only three specimens are known at present.

48.—Trochus, sp. Plate III. Fig. 13.

Description.—Specimen from the Coral Rag of Brompton (my Collection).

Length	7	millimètres.
Width	7·5	,,
Spiral angle	70°.	

Shell conical, trochiform, nearly equilateral, slightly wider than high. The spire is composed of few whorls, which are nearly flat, and ornamented by three rows of granulated costæ, the anterior row being slightly bicarinated, so as to make a sort of fourth row. Base flat; aperture subquadrate.

The specimen has suffered to a certain extent from exposure, so that the character of the ornaments is somewhat indistinct. Enough however remains to show that it cannot be referred to any of the species previously described.

EXPLANATION OF PLATE III.

Fig. 1. *Neritopsis decussata*, Münster. Coral Rag of North Grimston. Strickland Collection. × 1½.

,, 2*a* & *b*. *Neritopsis Moreauana*, D'Orbigny. Coral Rag of Brompton. Strickland Collection. Back and front. × 1½.

Fig. 3*a* & *b*.	*Neritopsis Guerrei*, Hébert and Deslongchamps. Coral Rag probably of Seamer or Ayton. Strickland Collection. Back and front. × 1½.
,, 3*c*.	*Idem.* Leckenby Collection. Natural size.
,, 4*a* & *b*.	*Turbo corallensis*, Buvignier. Coral Rag of Ayton. My Collection. Front and back. × 2.
,, 5*a* & *b*.	*Turbo Erinus*, D'Orbigny. Coral Rag of North Grimston. Strickland Collection. Back and front. × 2.
,, 6.	*Turbo lævis*, Buvignier. Coral Rag of Hildenley. Strickland Collection. Back and front. × 2.
,, 7*a* & *b*.	*Turbo* (*Delphinula*) *funiculatus*, Phillips. Coral Rag of Brompton. Strickland Collection. Back and front. × 1½.
,, 8*a* & *b*.	*Turbo* (*Delphinula*) *Pellati*, De Loriol. Coral Rag of Langton Wold. My Collection. Fragment, back and front. × 1½.
,, 9.	*Trochus obsoletus*, Rœmer. Passage-beds of the Lower Limestones. My Collection. × 2.
,, 10.	*Trochus acuticarina*, Buvignier. Corallian of Yorkshire. Leckenby Collection. × 2.
,, 11*a* & *b*.	*Trochus granularis*, sp.n. Corallian of Yorkshire. Leckenby Collection. Back and base. × 2.
,, 12.	*Trochus Aytonensis*, Blake and Hudleston. Base of Coralline Oolite, Pickering. Leckenby Collection. × 2.
,, 13.	*Trochus*, sp. Coral Rag of Brompton. My Collection. Natural size.

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

II.—On a Case in which various massive Crystalline Rocks including Soda-Granite, Quartz-Diorite, Norite, Hornblendite, Pyroxenite, and different Chrysolitic Rocks, were made through Metamorphic Agencies in one Metamorphic Process.

By Prof. James D. Dana, LL.D., A.M., For. Memb. Geol. Soc. Lond., of Yale College, New Haven, Ct., U.S.A.[1]

THE hornblendic and associated rocks referred to in the above title cover a large part of the township of Cortland—the north-western of Westchester County, New York—between Croton River on the south and the parallel of Peekskill on the north, an area of about 25 square miles. They differ widely from the ordinary rocks of the county, and may well be designated the Cortland series. In fact, a series so remarkable in constitution, so diversified in kinds, and so full of geological interest, is seldom found together within so small an area anywhere on the globe. They reach the banks of the Hudson just south of the Peekskill railroad station, and at several points beyond; yet considerable portions of the shore region are occupied by narrow strips of common kinds of mica schist and gneiss, and occasionally limestone. Leaving Peekskill by South street, near the river, the first ledges (*b*, on the following map) consist of one of the rocks of the series; and to the eastward of the village, on the road leading south-east, only half a mile from the Academy grounds (adjoining

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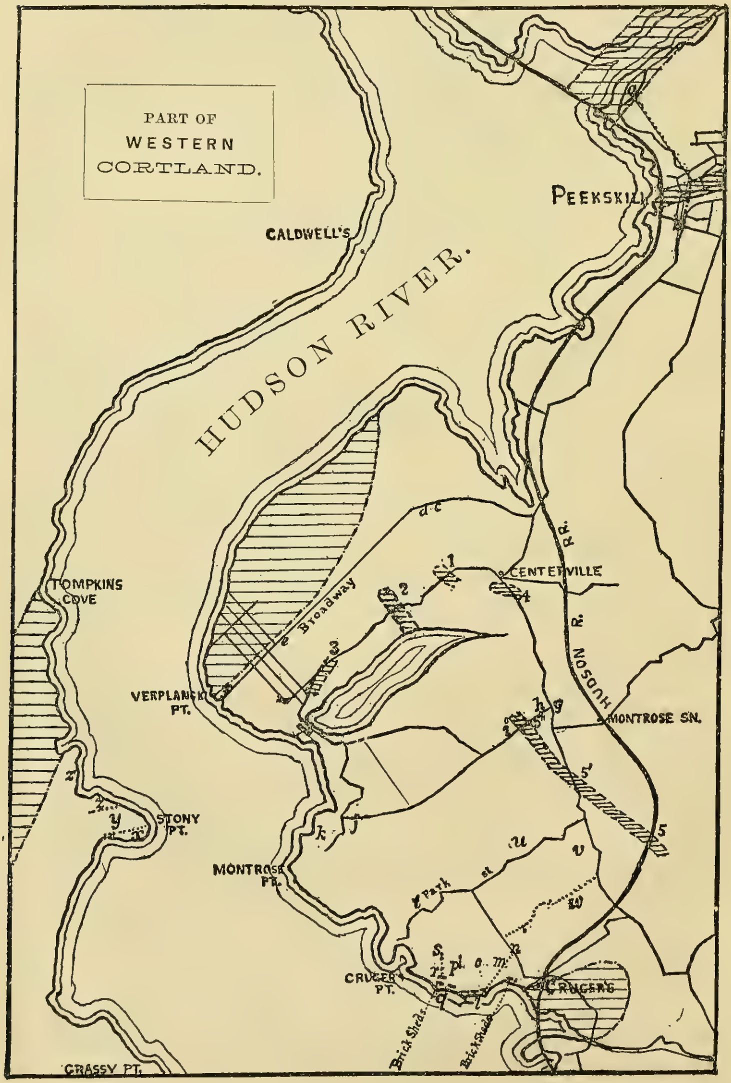
[1] This article is one of a series by Prof. Dana on the Limestone belts and associated rocks of Westchester County, New York, published in the American Journal of Science, volume 20. Westchester County is the Southern County of Eastern New York. The Hudson River bounds it on the west, and New York Island—the site of New York City—on the south. Its rocks are, with small exceptions, ordinary gneisses, mica schists, and crystalline limestone.

which, on the street north, an evenly-bedded mica-schist of the limestone series outcrops), the same rocks occur.

South of Verplanck they extend to the Hudson, and are the rocks of Montrose Point and the northern portion of Cruger's Point. Just here the river becomes narrowed to one-third of its width through the projection of these points and of an equally prominent headland called Stony Point on the opposite side. This isolated

2.



east-and-west ridge consists of rocks related to those of Montrose and Cruger's Points, and there is little doubt that it was once connected with the Montrose region. It is the only locality of the rocks yet observed on the western side of the Hudson.

The accompanying map of the western portion of the town of Cortland, between Peekskill and Cruger's, together with the Hudson River adjoining, contains the places here referred to. Its scale is an inch to a mile.

The occurrence of limestone areas in close proximity to the rocks of the Cortland series is a fact of special interest, as is shown beyond. These areas on the maps are those horizontally lined.

A brief description of the prominent varieties or kinds of these Cortland rocks will prepare the way for a discussion of their relation to the other rocks of Westchester County.

A. KINDS OF ROCKS.

The more prominent peculiarities in the constitution of these rocks (as learned by the aid of thin slices and microscopic examination) are as follows:

1. The felspars are chiefly triclinic species, or soda-lime felspars, though some orthoclase (potash-felspar) is also often present. They are therefore distinctively what many would call "*plagioclase*" rocks.

2. One or more of the minerals of the Amphibole group—hornblende, hypersthene, augite—are present in a large part of the rocks; of these, hypersthene is the most widely distributed. Its crystals, which are sometimes quite perfect, have the form of the augite common in volcanic rocks except that they are not oblique; they were ascertained to be true hypersthene through optical methods by Dr. G. W. Hawes.

3. Black mica or biotite is usually present, and sometimes abundantly, and in some of the kinds replaces wholly, or nearly so, the iron-bearing amphibole minerals.

4. Quartz is not a prominent ingredient, and in general is only sparingly present.

5. Chrysolite is a characteristic ingredient of some of the common kinds.

6. Apatite exists in microscopic and sometimes visible crystals in all the varieties; the largest crystal observed has a length of half an inch and diameter of a sixteenth. Magnetite is present in grains, and sometimes constitutes beds. Pyrrhotite also is disseminated through most of the rocks.

These crystalline rocks are commonly massive, that is, without bedding. They are everywhere jointed, and for this reason the ledges are generally piles of large and small blocks. In most places they undergo easy decomposition, making a grey or iron-red soil around; and, as the joints give access to water, the outer blocks in the pile have often become reduced to rounded and half-detached masses.

The rocks may be divided, for the convenience of the stratigraphic discussion beyond, into (1) the *non-chrysolitic,* and (2) the *chrysolitic.*

The former include four groups, based on the iron-bearing silicate prominent in the kinds; (A) the *Hornblendic*; (B) the *Hypersthenic;* (C) the *Augitic* ; and (D) the *Micaceous* or *Biotitic;* but the groups pass into one another by intermediate varieties. The chrysolite-bearing kinds are either (E) *hornblendic*, or (F) *augitic*, or (G) chiefly chrysolite; but here again intermediate kinds occur.

In the following descriptions I have confined myself to noting only the prominent distinctions so far as necessary to the stratigraphical discussion beyond.[1]

A. *The Hornblendic.*—The common hornblendic rock resembles syenite, but contains little orthoclase and much triclinic felspar. The latter is mostly of the species oligoclase, according to an optical measurement on cleavage slices. In addition, quartz is rather sparingly present. The rock contains more or less black mica and sometimes much of it; and as the mica increases at the expense of the hornblende, the rock passes into soda-granite (mentioned beyond). The quartz-diorite has the same relation to soda-granite that quartz syenite has to potash or common granite. Garnets are rare. The rock is often a very coarsely crystallized rock (*Aa*), having the hornblende crystals large, one-fourth to one-half an inch being a common size, and an inch and larger also common; and not unfrequently the black crystals are as large as the fingers, and occasionally six to eight inches long. A fine-grained variety (*Ab*) has a blackish colour; and this variety is sometimes porphyritic (*Ac*). The micaceous is another common variety (*Ad*). Another kind (*Ae*) is exceedingly fine-grained, and consists of minute grains of hornblende along with similar felspar grains, which are partly orthoclase; it looks much like hornblende schist, and in some places is schistose. It sometimes contains an occasional crystal of hypersthene. Another rock of the region is hornblendite, consisting almost wholly of hornblende. One variety (*Af*) is made up of coarsely crystallized black hornblende; another (*Ag*) of grey hornblende along with an asbestiform mineral. The black hornblendite graduates into diorite; and again, it is often chrysolitic.

B. *The Hypersthenic.*—The typical rock of this division (*Ba*) is the most widespread of the Cortland series. It consists of triclinic felspars (and, according to some trials, yet incomplete, by Dr. Hawes, oligoclase is the most abundant), hypersthene in grains or quite small crystals, with frequently more or less biotite, and often some orthoclase. There are also present some magnetite and apatite, frequently traces of quartz, and generally some augite or hornblende. In mineral constitution it approaches one of the kinds of rock that have been called both norite and hypersthenite or hyperite. The name *norite* is here given it provisionally. It, however, looks more like a coarsish dolerite or diabase than like other hypersthene rocks.

The norite has commonly a dingy brownish-red colour on a surface of fracture, owing to the smoky-red colour of the felspar, but varies from this to pale grey on one side and blackish-grey

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[1] A detailed study of the rocks of the Cortland region has already been begun, at my suggestion, by the accomplished lithologist, Dr. G. W. Hawes.

on the other. It occurs along the railroad between Peekskill and Montrose station, and over the most of the town of Cortland east of this line, and to some extent west.

This rock passes into a felspathic kind (*Bb*), consisting almost wholly of the felspars; and into a micaceous kind (*Bc*) containing very much black mica with little hypersthene—a very common variety, often occurring close alongside of the ordinary norite.

Although the norite is generally a massive rock, it is occasionally distinctly gneissic in structure, and sometimes contains a few garnets. The schistose variety usually abounds in black mica, or contains more quartz than other varieties, and sometimes more orthoclase.

C. *The Augitic.*—True augitic rocks are less common than hypersthene rocks, although augite is present in most of the massive rocks of the Cortland region. The chief kind (*Ca*) is pyroxenite—consisting mainly of pyroxene or augite, with sometimes a little hornblende; it varies from a very coarse rock with the augite crystals half an inch across, to a fine granular kind. A greenish-grey granular variety occurs on Stony Point in its chrysolitic region. Another kind (*Cb*) contains much triclinic felspar with the augite, and is here called *augite-norite*.[1] A local variety (*Cc*), related to the last, is light-grey in colour and smooth in fracture; it has a whitish felspathic base, seemingly almost felsitic, speckled with small spots or points of dark grey-green augite, and only traces of mica. The felspar in this variety, as slices show, is actually in fine crystalline grains; almost all of it is triclinic, as in other varieties. Chrysolitic kinds are mentioned beyond.

D. *The Micaceous.*—The micaceous rocks are of two prominent kinds. One (*Da*) is like a coarse granite in aspect; but its felspathic portion is chiefly triclinic, and quartz is sparingly present. It is characteristically a soda-lime granite, although containing some orthoclase, and it is a nearly quartzless variety of it. The mica is almost solely biotite or black mica. It is called beyond *soda-granite.* Some hornblende or augite is usually present; and apatite is common in small or minute disseminated crystals. It is sometimes sparingly garnetiferous. Good examples of this rock occur west of Cruger's railroad station above the brick yards; and also at Stony Point, where it is the prominent rock. At the former locality it graduates into the quartz-diorite; and at several places the coarsest of the diorite is found within a few yards of the typical soda-granite.

Another kind (*Db*) is a fine-grained black rock, often small-porphyritic. It owes its colour and texture to its having black mica in fine scales as its chief constituent. Like the preceding, it contains little quartz, and the felspar is almost wholly triclinic. Hornblende and augite are sparingly present. The rock is therefore a micaceous variety of the soda-granite. But, though ordinarily massive, it sometimes has distinct indications of bedding. The rock is most common in the vicinity of limestone belts. It occurs at Centerville,

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[1] This rock looks like the norite, but contains augite in place of hypersthene. If its felspar is chiefly labradorite (a point yet in doubt), it does not differ in mineral constitution from dolerite or diabase, or a prominent part of the so-called gabbro.

east of limestone No. 4 (see map), and also north of this limestone in the field west of the road, where it is conformable with the limestone.

E. *The Chrysolitic Rocks.*—The chrysolitic rocks of the region have no resemblance in aspect to ordinary chrysolitic volcanic or igneous rocks. The kinds are (1) *chrysolitic hornblendite,* (2) *chrysolitic pyroxenite,* (3) *chrysolitic norite;* and these graduate not only together, but also into a rock, in which chrysolite is the chief constituent. They are black or brownish-black rocks, and are mostly coarsely crystallized, the hornblende crystals being often an inch in length or breadth; and the chrysolite is in grains of various irregular forms and sizes, distributed through these crystals as well as among them, and not in well-formed crystals. In general, they contain but little felspar, and this is triclinic; and a variety intermediate between the hornblendite and pyroxenite is common. They contain occasionally black mica, but no quartz. The chrysolite is more or less altered, as is shown (when examined in thin slices) by the bordering and intersecting bands of magnetite and viridite, and in some cases it appears to be changed to serpentine.[1]

These rocks are largely exposed along the western half of the north side of Stony Point, west of the boat pier (the area is lettered *z z′* on the map), and over Montrose Point, as well as in its vicinity; at which places they are associated with norite and other rocks of the series. They also outcrop in eastern and southern Cortland. The most eastern locality observed is within half a mile of the eastern border of the town, near the middle of the three "emery" mines referred to beyond, and the most southerly, a short distance east of Croton, within half a mile of Croton River.

The chrysolitic rocks are the most decomposable of the series, and wherever the brown-black ledges are crumbling in an extraordinary way, and making a profusion of brown sand or brown or red earth, the presence of chrysolite may be suspected.

F. *Iron and Emery Mines.*—This Cortland region has its mines of magnetite, some of which are also mines of emery. The containing rock is either norite, diorite, or soda-granite, and even chrysolitic rocks are sometimes near by. The iron ore has been found at several points within a mile north and north-east of Cruger's, and also three or four miles distant in the eastern part of the township of Cortland; but the amount appears to be small, and no workings have yet proved profitable. The ore is commonly very chloritic, and contains less magnetite than the appearance and weight seem to indicate.

At a mine three-fourths of a mile north of Cruger's (at *u*, on

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[1] These chrysolitic rocks usually have, on a fresh fracture, the cleavage surfaces of the hornblende or augite spotted with chrysolite; but the presence of chrysolite, however abundant, cannot be made certain without slicing for microscopic examination, since the chrysolite is slightly altered externally, and such spots on hornblende crystals may be due to small imbedded crystals of augite. If the cleavage of the hornblende has an unbroken surface, it is probable that the rocks contain no chrysolite. The hornblendite has much stronger lustre than the pyroxenite.

the map), the including rock is a dark reddish-brown norite. The ore contains much chlorite, as shown by the grey-green tinge of its powder, and the green colour of transmitted light when in very thin slices. With it there are also garnet and some fibrolite in minute short needles. South-east of this locality (at *v* and *w* on the map) other openings have been made. Thin magnetite beds occur also on Cruger's Point, in the soda-granite and quartz-diorite, half a mile west of the railroad station. The material is fine-grained, nearly black in colour, chloritic like the preceding, and is usually associated with black mica. These beds are the subject of special descriptions beyond.

Among the localities in *eastern* Cortland, three are situated in a ridge or mountain running northward from Colabaugh Pond. One is at the southern end of the ridge, just north of the pond; another, near the road crossing it, about a mile farther north; and the third, at the north end of the ridge, nearly three miles from the pond, south of "Summer Hill." The magnetite, at each of these places, contains some disseminated corundum, making it a serviceable emery, and two of these mines have been worked for the emery; much of it also is chloritic. Fibrolite in small needles and divergent tufts is found with the ore at each locality.

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

III.—THE GLACIATION OF THE SHETLAND ISLES.

By B. N. PEACH, F.G.S., and J. HORNE, F.G.S.,
of the Geological Survey of Scotland.

Reply to Mr. Milne Home's Presidential Address before the Edinburgh Geological Society, May, 1880.

IN his valedictory address as President of the Edinburgh Geological Society, at the close of the session 1879-80,[1] Mr. Milne Home reviewed our recent paper on "The Glaciation of the Shetland Isles." [2] In his address he not only called in question our conclusions regarding the direction of the glaciation of these islands, but likewise referred to the discordance between the observations of Mr. C. W. Peach and ourselves. As much of this adverse criticism is based on a misconception of the real nature of the evidence bearing on the question, we are anxious to reply to some of the points in the address which might mislead those who are unacquainted with the subject.

In our paper we endeavoured to show that there were at least two periods of glaciation in these islands; the one being coincident with the climax of the Ice age, during which the islands were buried underneath the Scandinavian *mer de glace*, while the other was characterized by local glaciers which radiated from the high grounds in the ordinary way. We stated as the result of a careful examina-

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[1] Trans. Edin. Geol. Soc. vol. iii. part 3, p 357.

[2] Quart. Journ. Geol. Soc. vol. xxxv. p. 778.

tion of the striated surfaces, and specially of the dispersal of the stones in the Boulder-clay, that, during *the primary glaciation*, the Scandinavian ice-sheet abutted on the eastern seaboard of Shetland with a W.S.W. and S.W. trend, and after reaching the crest of the Mainland, it swung round to the N.W. and N.N.W.

With reference to this statement, Mr. Milne Home makes the following remark: "Even on the east coast of the Shetlands, where the striations should show a N.E. direction, there is no uniformity in that direction. Near the south end of the group, viz. at Bressay and Lerwick, as the arrows on the map show, the direction of the striæ is not from N.E. to S.W., but from N.W. to S.E."

No reference is made in the foregoing sentence to the fact that the south-easterly striæ at Lerwick and at certain localities in Bressay belong to the period of local glaciation. Neither is any allusion made to the existence of cross-hatches along the shore at Lerwick; the older markings running S.W., and the newer ones S. 40° E. Moreover, we distinctly pointed out in our paper, that the south-westerly movement of the ice-sheet during the primary glaciation in the Lerwick and Quarff districts is placed beyond doubt, by the occurrence of striated blocks of Old Red Sandstone grits and flags in the Boulder-clay on the west side of the island near Quarff. On the other hand, we indicated that the presence of striated fragments of schists and slates from the Cliff Hills, in morainic deposits in the neighbourhood of Lerwick, points to a local radiation of the ice which was only powerful enough to invade the north-western part of the island of Bressay.

Regarding the direction of the ice-flow in Unst, Mr. Milne Home says: "Also at the north end of the group of islands, viz. in Unst, though the authors of the paper represent by contour lines, and also by the text, the direction of the movement to have been from N.E. to S.W., considerable doubt must be felt on that point because of the contrary testimony of Mr. C. W. Peach, as given in the British Association Reports for 1864. Mr. Peach states 'that ruts and striæ fell under his notice in North Unst, on the cliff at Hagdale in Haroldsnick Bay; the direction being nearly W.N.W. and E.S.E.' Mr. Peach says 'that in ascending the Muckle Heog Hill, which reaches a height of at least 500 feet, he found the W.N.W. end vertical and polished, to the depth of 150 feet.'"

The discrepancy between the observations of Mr. C. W. Peach and ourselves may be best explained by quoting from a letter dated November, 1880, which he has kindly forwarded to us, and which he has permitted us to use in our reply to this address. "I send you a copy of my paper on Shetland, read before the Royal Physical Society, Edinburgh, in which I stated that the striæ on the Muckle Heog, Unst, ran nearly W.N.W. and E.S.E. In the closing sentence of that paper I also stated that all the bearings are by compass, no allowance having been made for variation. This should be taken into consideration and the deviation allowed for as far as Shetland is concerned. Since I wrote that paper, having seen much more of the glaciation of Scotland and thought more about it, I have seen cause to alter my opinion as to the direction of the drift over Shetland, viz. the opposite of what I inferred in my paper to the Royal Physical Society. At the time I wrote (1864), I was much puzzled, when examining the Boulder-clay near Hammer in Balta Sound, to find mingled with the striated stones of serpentine, numerous striated stones of gabbro from Balta Island ; and then at the haunted burn of Watlea, where the black shales are exposed and in which lies the Boulder-clay containing smoothed and striated stones of serpentine in abundance, when beyond the Skaw to Saxaford Hill I met with no trace of serpentine or gabbro stones, although I searched rather carefully. I now feel quite satisfied, that although I noticed the bearing of the striæ right, I was wrong as to the direction the drift came from. At that time I was full of dredging matters, and my mind ran so much after Hydrozoa, Polyzoa, Crustacea, Mollusca, etc., that I had little time for examining the glaciation of the islands, and hence the oversight and neglect of the warnings of Hammer and Watlea, for which I am sorry."

The candid admissions contained in this letter enable us to account for the discordance between the recorded observations of Mr. C. W. Peach, in 1864, and ourselves. We visited the locality at Hagdale, referred to by Mr. Peach, sen., and confirmed the accuracy of his observations so far as the magnetic readings are concerned. When due allowance is made for the magnetic deviation, the *true* direction of the ice-flow at Hagdale is nearly E. and W., as noted by us. Along the eastern seaboard of Unst, however, the striæ vary from W. to W. 30° S. ; the westerly trend being more prevalent in the northern part of the island. From the foregoing letter it is also evident that Mr. C. W. Peach had observed certain facts connected with the dispersal of the stones in the Boulder-clay which unquestionably point to the westerly movement of the ice. He noted the occurrence of gabbro stones from Balta Island in the Boulder-clay at Hammer, and striated serpentine fragments in the Boulder-clay at Loch Watlea to the *west* of the serpentine area. These facts are not referred to in any of the papers which he wrote on the subject at that time, doubtless for the simple reason that they are inexplicable on the hypothesis which he then adopted of an ice-movement from the W.N.W. and N.W. Had he found time, in the midst of his dredging operations, to traverse the western shore of Unst, between Woodwick and Belmont, he would have met with still more convincing proofs of this westerly movement in the presence of serpentine and gabbro stones in the Boulder-clay, which must have been carried across the water-shed. Indeed, so abundant are these striated fragments in this deposit on the west coast, that it is impossible to escape the conclusion, that the ice must have crossed Unst from the North Sea to the Atlantic.

In 1868, Mr. C. W. Peach informed Dr. Croll[1] that a minute examination of the shelly Boulder-clay of Caithness, continued for several years, had led him to the conclusion that the ice must have

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[1] Geol. Mag. 1870, p. 212.

crossed the low grounds of that country from the S.E. towards the N.W. His faith in the north-westerly movement in Unst seems then to have wavered, but no subsequent opportunity was afforded him of re-visiting Shetland to examine the evidence anew.

To quote further from the address: "Mr. Peach is a geologist of such experience and strict accuracy that observations by him need no corroboration; but Professor Geikie, in an article in 'Nature,' of 17th September, 1877, refers to the foregoing report by Mr. Peach, and says that from his own observations he can speak confidently as to the correctness of Mr. Peach's determinations." In the article referred to, Professor Geikie confirms Mr. Peach's determinations only with reference to the occurrence of abundant striated rock surfaces, and Boulder-clays with striated stones, in the Shetland islands, the existence of which had been doubted by S. Laing, Esq, M.P. He carefully avoids expressing any opinion regarding the direction of glaciation of these islands, and so far as we are aware he has never published any opinion on this question.

Mr. Milne Home further says: "With regard to the west coast of the islands, where the markings are N.W. and S.E., the authors state that these indicate a movement from the S.E. But the nature of the evidence to show that the movement was from the S.E. and not from the N.W. is not given."

We are at a loss to understand how any one who has attentively read our description of the Boulder-clay sections, could possibly conclude that the nature of the evidence for the north-west movement on the west side of the Mainland is not given. We described with considerable minuteness a series of Boulder-clay sections[1] extending across Northmavine from Ollaberry by Hillswick, Braewick. Tanwick, to the Grind of the Navir and similar sections along the banks of Roeness Voe. On referring to the map accompanying our paper, it will be seen that the lithological varieties of the rock-masses along these lines of section are so distinct as to render it an easy matter to determine the direction of the ice-movement, from the dispersal of the stones in the Boulder-clay. We distinctly indicated that the ice-carry between the diorite area east of Hillswick and the cliffs north of the Grind of the Navir was *towards the north-west.* We pointed out that the quartz-felsite and granitic area was invaded by the diorite stones, and the area occupied by the contemporaneous porphyrites and tuffs was invaded by the diorite and quartz-felsite stones; the relative ingredients diminishing in number in proportion to the distance from their parent source. Furthermore, in the peninsular tract which lies to the west of Weesdale, we stated that corroborative evidence is obtained of this north-westerly movement on the west side of the Mainland. To the east of the north and south bounding fault which crosses the peninsula from Aiths Voe to Bixetter and Selie Voes, no trace of the altered Old Red Sandstone rocks are to be found, either in the Boulder-clay or on the surface, while numerous blocks of the epidotic syenite and the associated

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[1] Quart. Journ. Geol. Soc. vol. xxxv. p. 796, et seq.

gneisses and schists are met with to the west of the fault. And so also in the island of Papa Stour numerous striated blocks of the altered Old Red rocks from Sandness Hill are commingled in the *moraine profonde* with fragments of the local porphyry and contemporaneous diabase porphyrites, while in the neighbourhood of Melby the Boulder-clay sections may be searched in vain for blocks derived from Papa Stour. It requires only a moment's reflection to see that the phenomena would have been precisely *the reverse* of what we have just described, had the ice-movement been *from* the north-west, as Mr. Milne Home imagines. Indeed, as we stated in our paper, "the evidence obtained from the Boulder-clay along these lines of section completely refutes the theory that these north-westerly striæ could have been produced by ice coming from the North Atlantic."

Mr. Milne Home concludes his review by stating that "the authors of this paper, besides maintaining that the Shetlands were glaciated by a *mer de glace* from Scandinavia, have gone so far as to suggest that the whole of Scotland underwent a glacial invasion from the same quarter; and they give reasons for this opinion which are not very intelligible."

The only ground for this statement is the following sentence in the conclusion of our paper: "The land-ice which glaciated *Scotland* could only have come from Scandinavia, as the striated surfaces clearly point in that direction." Owing to an unfortunate printer's error, for which we are sorry, the word Scotland in the foregoing sentence has been substituted for Shetland; an error which is self-evident to any ordinary reader after a careful perusal of the context. We do not believe that any part of Scotland was ever over-ridden by the Scandinavian *mer de glace*; indeed, there is not the slightest evidence in support of such an hypothesis. So far from this being the case, we have advanced sufficient evidence to prove that the Scotch ice-sheet must have spread far enough over the floor of the North Sea as to over-ride the Orkney Islands.[1]

We have now disposed of the various points in this address which are likely to mislead the general reader. We have spent our annual holidays for four years in working out the glacial phenomena of Shetland, Orkney and Caithness, with a view to determine the question of the extension of the ice in the North Sea during the Glacial period. In the course of these traverses we have amassed a great amount of detailed evidence, which cannot readily be incorporated in the pages of a scientific publication like the Quarterly Journal of the Geological Society. We have had to content ourselves with merely summarizing the evidence. We can only state, however, that our repeated traverses have left no escape from the conclusion, that *during the climax of the Glacial period*, the direction of the ice-movement in Shetland, Orkney, and Caithness was from the North Sea and the Moray Firth towards the Atlantic.

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[1] Quart. Journ. Geol. Soc. vol. xxxvi. p. 648.

IV.—NOTES ON A COLLECTION OF BIVALVED ENTOMOSTRACA AND OTHER MICROZOA FROM THE UPPER-SILURIAN STRATA OF THE SHROPSHIRE DISTRICT.

By J. SMITH, Esq., of Kilwinning.

With a Provisional List of Species, by Prof. T. RUPERT JONES, F.R.S., President Geol. Assoc.

INTRODUCTION.

DR. HARVEY B. HOLL, F.G.S., has obtained many very perfect Silurian Entomostraca, and the late Lieutenant Henry Adrian Wyatt-Edgell got some good specimens from the Border Counties; and indeed Dr. Holl made an extensive and valuable collection from the limestones and shales of the neighbourhood of Malvern; nor has his collection been fully described and illustrated as yet, although several selected forms have been published in the "Annals of Natural History," for December, 1865, and March, 1869. The remarkably rich collection of Silurian Entomostraca, however, brought together by Mr. J. Smith, of Kilwinning, contains some of the finest specimens yet seen; and the following notes on the places where they were obtained, and a list of the species (although provisional only, and not fully worked out), must be of interest, and probably of some practical value both to the geologists of Shropshire and to palæontologists in general.—T. R. JONES.

I.—*Method of Preparation and Search.*

The plan taken in searching the following localities for *Entomostraca* and other *Microzoa* was to collect on the shale-banks, where that material was thoroughly decomposed, in natural sections and old quarries, always lifting some of the larger fossils along with the decomposed shale. After collecting ten or twelve pounds weight of the shale, all over the spoil-banks or the section, so as to get a fair average sample, it was put into a small riddle, with $\frac{1}{8}$ inch mesh, and washed in the nearest water into a buckram bag, three feet long by ten inches wide, the larger fossils remaining in the riddle. The shale was then further washed in the bag until *most* of the fine mud (decomposed shale) had floated away through the meshes of the buckram. After taking this home (reduced now in weight to a few ounces), it was first dried, then boiled in water for half an hour, and then washed in a basin, clean water being added until all the fine mud had floated away. In the process of washing, care was taken only to pour the water on the shale, never to rub it with the hands, as this treatment is sure to break delicate fossils, such as Sponge-spicules, Conodonts, etc. The washed material, having been dried, was successively passed through four fine sieves, from $\frac{1}{16}$th to $\frac{1}{80}$th of an inch in the mesh. The coarser material was searched with the naked eye, and the finer under the microscope.

II.—*The Localities of the Upper-Silurian Entomostraca and other Microzoa.*

1. WALSALL.—This gathering was taken at Blue Holes, near the

Rushall Canal. It turned out rather poor, only a few Brachiopods having been got besides the *Entomostraca* mentioned in the list.

One species of *Entomostraca.*

2. SEDGLEY.—Wenlock-Limestone Shale. This fine yellowish shale yielded several species of small Brachiopods, some fragments of Crinoids and Polyzoa, but was by no means rich in Microzoa.

Two species of *Entomostraca.*

3. THE WREN'S NEST, NEAR DUDLEY.—The gathering of shale from this locality was particularly rich in small Brachiopods. Fragments of Crinoids were not uncommon. A few pieces of Polyzoa and some *Spirorbes* turned up.

Three or four species of *Entomostraca.*

4. DUDLEY-CASTLE GROUNDS.—This gathering contained a number of small Brachiopods, and fragments of Crinoids, Polyzoa, and *Tentaculites.*

Three species of *Entomostraca.*

5. DUDLEY-TUNNEL DÉBRIS. — The Microzoa in this lot were mostly small Brachiopods. This is a good locality for the collector of the larger Silurian fossils, if he likes to dig into the shale-heaps. We have seen splendid specimens of Corals, etc., from this place such as the Chain, Pipe, Honey-comb, Sun, and other Corals.

Four species of *Entomostraca.*

6. RAILWAY-CUTTING, COALBROOKDALE.—This gathering, a fine yellowish shale, was exceedingly rich in Microzoa, including an abundance of *Entomostraca.* Small Brachiopods were plentiful, Crinoids common (more than 30 small "heads" turned up), several specimens of small rugose Corals and Polyzoa. Fragments of the eyes of Trilobites, showing both the inside and outside of the facets, were not uncommon. Small specimens of Tentaculites were frequent.

Three or four species of *Entomostraca.*

7. RAILWAY-CUTTING BY THE SIDE OF THE SEVERN NEAR IRONBRIDGE.—This section is exposed in the railway-cutting on the west side of the river, nearly opposite the Swan Hotel. The shale in the cutting lies about 150 feet below the Benthall-Edge Limestone (Wenlock). It is richer in *Entomostraca* than any other Silurian shale which I have examined. As usual, small Brachiopods are common. Remains of Crinoids and Polyzoa not unfrequent.

Eighteen or more species of *Entomostraca.*

8. BENTHALL EDGE.—This picturesque locality should not fail to be visited by the student of Silurian Palæontology. Here abundance of the larger Silurian fossils are always to be obtained. Corals, Brachiopods, and Gasteropods are common; and good Trilobites sometimes turn up to the diligent searcher. With the Microzoa the Brachiopods, as usual, predominate. Crinoidal remains are frequent. Some small *Gasteropods* and a few *Spirorbes* occurred in this gathering.

Four species of *Entomostraca.*

9. LINCOLN HILL.—This locality is exactly behind the Swan Hotel, Ironbridge. Small Brachiopods and Crinoids are frequent. A few

Polyzoa and a large number of *Spirorbes* were found in this lot. Several small rugose Corals also were got.

Five or six species of *Entomostraca.*

10. GLEEDON HILL.—Fine yellowish shale, in a quarry by side of the railway, between Buildwas and Much-Wenlock. Small Brachiopods and Crinoids frequent; Polyzoa rare.

One species of *Entomostraca.*

11. RAILWAY-CUTTING NEAR MUCH-WENLOCK.—This section is about a mile N.E. from Much-Wenlock Station. Fine yellowish shale. Small Brachiopods are common in this shale. A few *Spirorbes* and some fragments of Polyzoa turned up.

Five species of *Entomostraca.*

12. ESKAM-ENGHAM.—This locality is about two miles west from Newent. Fine yellowish shale in an old quarry. Contains frequent Brachiopods, Polyzoa, and Crinoid remains.

One species of *Entomostraca.*

13. WOOLHOPE.—Small quarry on the Ledbury Road, about one mile from Woolhope Inn. Fine bluish shale. Small Brachiopods common; Crinoids frequent. A large number of beautiful fragments of Polyzoa were met with in this gathering.

Ten or eleven species of *Entomostraca.*

14. DORMINGTON WOOD.—Three miles S.W. from Stock-Edith Station. Fine bluish shale. The larger Silurian fossils abundant. Small Brachiopods and Crinoids frequent; with a few fragments of Polyzoa.

Two species of *Entomostraca.*

15. STOCK-SAY.—About two miles south of Craven Arms Station. Fine yellowish shale in an old quarry. Small Brachiopods abundant. Polyzoa, Crinoids, *Spirorbes,* and *Tentaculites* frequent.

Three species of *Entomostraca.*

16. MALVERN TUNNEL.—16*a*. *Red Shale.*—This section is in the railway-cutting at the west end of Malvern Tunnel. The shale is not so fine-grained as any of the preceding. Small Brachiopods, Crinoids, and rugose Corals frequent. Minute Tentaculites were common in this gathering.

Three species of *Entomostraca.*

16*b*. *Blue Shale.*—At the same place as the last, but rather nearer the mouth of the tunnel. Like the last, this shale is rather coarse-grained. Few minute fossils.

Two species of *Entomostraca.*

III.—*Further Observations.*

In all the above-mentioned gatherings of shale, I failed to find even a single *small* specimen of either a Cephalopod or a Lamellibranch; and very few large ones belonging to these orders.

Pearls (?).—In the shale at Sedgley, Woolhope, Dormington, Lincoln Hill, Benthall Edge, and Gleedon Hill, a number of minute spheroidal bodies occurred. Some are silvery white, some yellowish, and others of a dark-brown colour when viewed by reflected light. All of them have a peculiar pearly lustre. One that had been split through the middle shows a concentric laminated structure.[1] On washing some of the rotted limestone from the Much-Wenlock quarries, I found these pearls (?) very abundant.

Foraminifera (?).—Lagena-like bodies were got from the gatherings at Lincoln Hill, the Railway-cutting by side of the Severn, Benthall Edge, Woolhope, and Dormington.

Conodonts.—At the Wren's Nest, Dudley Tunnel, Benthall Edge, Lincoln Hill, Gleedon Hill, and Dormington Wood, a few Conodonts were found in the washed shale. Conodonts are very abundant in a rotted limestone (Upper-Silurian) near the Craven Arms. No Entomostraca were found in this rotted limestone.

Sponge-spicules.—From the gatherings at the Wren's Nest, Lincoln Hill, Benthall Edge, Dormington Wood, and Malvern Tunnel, a few three- and six-rayed Sponge-spicules were got.

Spicules of *Hyalonema* (?) are very abundant, along with the Conodonts, in the rotted limestone near the Craven Arms.

IV.—List of Species (provisional) of Bivalve Entomostraca, etc., collected by Mr. J. Smith, of Kilwinning, from the Upper-Silurian Formations of Shropshire. By Professor T. RUPERT JONES, F.R.S., F.G.S.

1. Blue Holes, Rushall Canal, Walsall.
   Beyrichia Klœdeni, M'Coy, var. *intermedia*, Jones.
   ,, ,, M'Coy, var. *subtorosa*, Jones.
2. Sedgley.
   Primitia Rœmeriana, Jones & Holl.
   Cythere corbuloides (?), J. & H.
   Lagena vulgaris, Williamson, var. *clavata*, D'Orb.
   Pearls (?).
3. The Wren's Nest, Dudley.
   Primitia variolata, J. & H.
   Beyrichia Klœdeni, M'C.
   ,, ,, ,, var. *tuberculata*, Salter.
   Spirorbis.
   Conodonts. *Spicules*.
4. Dudley Castle Grounds.
   Primitia Rœmeriana, J. & H.
   Beyrichia Klœdeni, M'C.
   ,, ,, var. *torosa* (with large lobes), Jones.
   Cythere, sp.
5. Dudley Tunnel.
   Primitia Salteriana, Jones (? = *P. prunella*, Barrande).
   Beyrichia, sp.?
   Cytherella, sp.
   Cythere bilobata (?), Münster. (A Carboniferous form.)
   Conodonts.
6. Railway-cutting, Coalbrookdale.
   Æchmina cuspidata (?), J. & H.
   Primitia variolata (?), J. & H.
   Beyrichia Klœdeni, M'C.
   ,, ,, var.?
7. Railway-cutting by the side of the Severn, Ironbridge.
   Primitia renulina, J. & H.
   ,, *variolata*, J. & H.
   ,, *Salteriana*, J., var. (bituberculate)?
   ,, sp. (Long, like *P. protenta*, J., but without the two tubercles; and like *P. fusus*, Barrande, but more cylindrical).
   Kirkbya, sp.?
   Beyrichia Klœdeni, M'C. (In old and other conditions.)
   ,, ,, var. *intermedia*, J. (With a big lobe.)
   ,, ,, var.?

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[1] Some small spherical bodies regarded as *fossil pearls* were described and figured by Prof. John Morris, in the "Annals Nat. Hist." for August, 1851. One specimen was from a Jurassic *Gryphœa*, obtained from the Drift at Muswell Hill near London; and the others were from the Chalk of Kent.

   - *Beyrichia*, sp. (Very much like *B. radiata*, J. & K. MS., a Carboniferous form.)
   - „ sp.
   - *Æchmina cuspidata*, J. & H.
   - *Thlipsura corpulenta*, J. & H.
   - „ V-*sculpta*, J. & H.
   - *Cythere corbuloides* (?), J. & H.
   - „ *bilobata* (?), Münster. (A Carboniferous form.)
   - „ 2 sp.
   - *Paracypris*, sp. (Like a long *Bairdia*?)
   - *Polycope*?
   - *Lagena*.
   - *Spirorbis*.

8. Benthall Edge.
   - *Primitia variolata* (?), J. & H.
   - *Beyrichia Klœdeni*, M'C.
   - *Cytherella*, sp.?
   - *Cythere*, sp.?
   - *Lagena*.
   - *Conodonts*. *Spicules*. *Pearls* (?).

9. Lincoln Hill, Ironbridge.
   - *Primitia Rœmeriana*, J. & H.
   - „ *variolata* (?), J. & H.
   - „ „ var.
   - *Beyrichia Klœdeni* (?), M'C.
   - *Cythere*, sp.
   - *Lagena*.
   - *Conodonts*. *Spicules*. *Pearls* (?).

10. Gleedon Hill, Much-Wenlock.
    - *Beyrichia tuberculata*, Klœden. (Fine old specimen.)
    - *Conodonts*. *Pearls* (?).

11. Railway-cutting near Much-Wenlock.
    - *Primitia*, sp. (Long form, like that in No. 7.)
    - *Beyrichia Klœdeni*, M'C., var. intermedia, J.
    - „ sp.
    - *Thlipsura tuberosa*, J. & H.
    - *Cythere*, sp.
    - *Spirorbis*.

12. Eskam-Engham, near Mayhill.
    - *Thlipsura*, sp. (Very faint end-mark.)

13. Woolhope.
    - *Isochilina* (or *Leperditia*?), sp.
    - *Primitia excavata*, J. & H.
    - „ sp. (Reticulate.)
    - „ sp. (Oval.)
    - *Æchmina cuspidata*, J. & H.
    - *Beyrichia tuberculata* (?) Klœden. (Old individual.)
    - „ *Klœdeni*, M'C.
    - „ „ var. *tuberculata*, Salter.
    - „ „ var.?
    - „ sp.?
    - *Cytherella*, sp.?
    - *Thlipsura*, sp.?
    - *Lagena*.
    - *Pearls* (?).

14. Dormington Wood, Benthall Edge.
    - *Beyrichia Klœdeni* (?), M'C.
    - *Thlipsura corpulenta*, J. & H.
    - *Lagena*.
    - *Spirorbis*.
    - *Spicules*. *Pearls* (?).

15. Stocksay.
    - *Primitia variolata* (?), J. & H. (Crushed specimen.)
    - *Beyrichia tuberculata*, Klœden. (Cast.)
    - *Cytherella*, sp.
    - *Cythere*, 2 sp. (Resembling *C. æqualis*, J. & K. MS., and *C. obtusa*, J. & K. MS., from the Carboniferous Formations.)

16. Malvern Tunnel, West End.
    - *a*. Red Shale.
      - *Primitia Rœmeriana* (?), J. & H.
      - *Thlipsura corpulenta*, J. & H.
      - *Cythere*, 2 sp. (Like those in No. 15.)
      - *Spicules*.
    - *b*. Blue Shale.
      - *Thlipsura corpulenta*, J. & H.
      - *Cythere*, sp.
      - *Spicules*.

17. Craven Arms, rotten limestone near the.
Spicules (3- and 6-rayed).
Conodonts.
Pearls (?).

The *Lagenæ* (mounted on one slide) from Lincoln Hill, the Railway-cutting at Ironbridge, Dormington, Woolhope, and Benthall Edge, comprise:
Lagena vulgaris, Williamson, var. *lævis*, Montagu (with tubuliferous neck).
" " " " *clavata*, D'Orb.
" " " " *sulcata*, Walker and Jacob.

The close correspondence of the Recent with these Silurian forms is very noteworthy.

The presence, also, of some Entomostracan species apparently identical with Carboniferous forms is to be noted as an additional example of recurrence (like the Silurian *Beyrichia intermedia* in the Carboniferous Limestone of Russia). The presence, also, in these old deposits of *Entomostraca* indistinguishable, as to valves, from recent genera, should not be lost sight of.

I submitted Mr. Smith's Collection of Upper-Silurian *Entomostraca* to my friend Mr. J. W. Kirkby, and he favoured me with the following remarks:—

"With this I return you Mr. Smith's Silurian Entomostraca, which I thank you for the sight of. They are the best Silurian specimens that I have seen. Some of the *Cythere*-like forms appear to come pretty near Carboniferous species, as you pointed out to me. A set on one slide can scarcely be distinguished from Münster's *Cythere bilobata*, and on other slides there are specimens that I suppose we should have named *C. æqualis*, J. and K., and *C. obtusa*, J. and K., had they been found in Carboniferous strata."

V.—OCEANIC ISLANDS.

By T. MELLARD READE, C.E., F.G.S.

THE Pacific and Atlantic Oceans far from the continental masses of land are studded with islands, which from their being solely volcanic and of an age going back no further than the Tertiary period, are considered to lend great support to the hypothesis of the permanence of the great oceans and continents. Those who hold these views question the right of New Zealand to be considered a truly oceanic island, though on what grounds has never been quite intelligible to me. Waiving this objection for the purpose of argument, I propose to discuss the bearings of the facts, as formulated by those who believe in the "approximate" immutability of land and sea.

But before this can be done it will be necessary to consider the vertical limits within which Dr. Darwin's generalization, that the "great oceans are still mainly areas of subsidence, the great archipelagoes still areas of oscillation of level, and the continents areas of elevation,"[1] could have acted. An approximate calculation tells me that had one-half of the ocean floor subsided 1500 feet since Cambrian times, the period Dr. Darwin adopts for the commencement of this state of things, the then land, if it possessed the

[1] Origin of Species, 4th edit. p. 373.

present contours of our continents, would have been submerged to about the 700 feet contour. It is impossible at present to calculate with exactness to what extent this would reduce its surface, but probably one-half. If, on the other hand, the land had risen since Cambrian times 1500 feet, it is evident there must have been very little of it to commence with. Therefore, if there has been a preponderance of depression in the oceans and of elevation in the land since Cambrian times, it has acted within very narrow limits, or there would not have existed land enough to provide sediment for the construction of the enormous thickness and extent of the later sedimentary rocks we know of, to say nothing of those which under my hypothesis must be admitted to extend more or less under the sea-bed.

The volcanic oceanic islands are mostly based upon submarine plateaux, one of which in the Pacific extends from Cape Horn in a north-westerly direction to Tahiti, a distance of some 80 degrees of longitude and 30 degrees of latitude, at a depth of about 1000 fathoms.[1] It is conceivable, if these plateaux were areas of oscillation of level, that the vertical limits of movement may have been too small to have produced by that means continental islands, and it is also conceivable, though not probable, that the plateaux may now all be at the downward limit of oscillation.[2] Now comes my argument.

The lapse of time between the Cambrian and Tertiary periods was vastly greater than that between the commencement of the Tertiary and the present time. I will not presume to say how much more, because authorities differ, but Dana puts it down, as nearly as I can interpret him, at about fifteen times as great.[3] Are we then to assume that during all this vast interval of time, and over an immense extent of the ocean floor, the volcanic forces of the earth, which some physicists maintain have been gradually dying out, lay dormant, so that no volcanic island or land was built up from even a depth of 1000 fathoms—not two-thirds the height of Etna? And are we to go further, and say that this stable state of equilibrium was suddenly disturbed by volcanic eruptions during and since the Tertiary period, by which what are called the Oceanic islands were created? I think neither physicists nor geologists will admit this to be probable without very strong evidence, which has yet to be given.

It may be said in reply that such Palæozoic or Secondary volcanic islands may have existed and become since destroyed by atmospheric or oceanic waste; but this admitted, cuts the ground from under the argument, as the same forces would also have destroyed sedimentary rocks, the absence of which is accounted a proof of the permanence of the oceans and continents.

Properly considered, then, the argument drawn from the volcanic or non-sedimentary nature of the so-called oceanic islands is, as usual with negative evidence, not very much to be relied on. Nay,

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[1] Thalassa, pp. 21-2.

[2] This is disproved by Dr. Darwin's own observations.

[3] Manual of Geology, 2nd edit. p. 586.

to me it seems rather to point to the fact that the condition of things oceanic since the commencement of the Tertiary period differed and still differs from that which existed in earlier times, and is therefore, looking at it in this light, rather against than for the hypothesis that the oceans and continents occupy permanent positions on the earth's surface.

The distinguished author of the "Origin of Species," so fertile in suggestions, yet so fair in judgment, while upholding in a letter to the writer his published views[1] on the subject, considers, as we all must, that it is full of perplexities, and that the more it is discussed the better.

VI.—ON THE DISCOVERY OF A NEARLY ENTIRE *RHIZODUS* IN THE WARDIE SHALES.

By THOMAS STOCK, Esq.,

Natural History Department, Museum of Science and Art, Edinburgh.

(Read before the Edinburgh Geological Society, 16th December, 1880.)

THE fact of the occurrence of *Rhizodus* at Wardie has been known for a good many years. It appears as an addendum to a list of fossils from that locality published[2] in 1861 by the Geological Survey of Scotland. The specimens hitherto collected, however, have been the merest fragments, consisting principally of detached scales. Almost the first fossil obtained by the writer from Wardie was a badly-preserved fragment of the jaw of *Rhizodus* containing teeth. Since then a few fragments have occurred referable to the same genus. From the fact that these were invariably found along a particular part of the beach, the suspicion was gradually awakened that they had been derived from a common source. This suspicion was confirmed by the discovery of the remarkable specimen which is the subject of this notice. It was found lying in the direction of the strike of the beds, its head seawards, its tail to the shore. The greater part of it was buried under from six inches to a foot of shale. The end of the tail and the anterior portion of the head had been bared by the waves, and though the tail remains almost intact, the head has suffered a good deal from the erosion of the sea. The rest of the fish is preserved. As the bed in which it was entombed is accessible only at very low-water, considerable difficulty was experienced in getting the specimen away; but, thanks to the help of Mr. Macpherson of Trinity, this was effected, and a noble fish has been saved to science.

It is undesirable at present to say much about the new facts which this specimen reveals. Much may be made out as to the shape of the fish and the position of the fins; but it would be unwise to give forth statements involving facts of great structural importance until these can be corroborated by examination of the fish, after it

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[1] I am indebted to Mr. Topley for calling my attention (GEOL. MAG. Dec. 1880, p. 573) to Mr. Darwin's views.

[2] The Geology of the Neighbourhood of Edinburgh, London, 1861.

has been properly developed and displayed. It will be enough to say that it appears to be in a good state of preservation; that it is nine feet in length; and that it occurs in the form of an immense flat nodule. A few detached scales were found in nodules beside it; but beyond this and the injury the head has received from the sea, there has been no disintegration of importance.

The remains of *Rhizodus* hitherto obtained have been of a very fragmentary nature.

Ure[1] figured a part of a mandible with teeth.

Dr. Hibbert's[2] material, though more abundant, was very little better.

M'Coy[3] says that its general form is unknown.

Mr. John Young, F.G.S.,[4] noticing its occurrence near Glasgow, says, "No large fragments of either the internal skeleton or the outer covering of scales, have yet been found in this locality. In the E. of Scotland, *R. Hibberti* is very common in the Burdiehouse Limestone, and in one or two localities in the Fifeshire Coal-field; but no perfect examples have yet been found, so that its general form is unknown."

Professor Young[5] remarks that "no fragments have yet been found from which the shape of the body or the structure of the head can be determined."

Professor Miall,[6] in a clear and able paper, describes "a large and tolerably perfect skull," and observes, "Much yet remains to be known of the Carboniferous genus *Rhizodus*, of which only the teeth, scales, pectoral arch, jugular plates, and mandible have hitherto been identified."

American authors[7] have referred fragments to *Rhizodus*, but they do not seem to have been so fortunate as ourselves with this fish.

The specimens in the Edinburgh Museum of Science and Art, many of them very fine, are all fragmentary, so that there is abundant warrant for saying that the Wardie *Rhizodus* is the first yet obtained in a nearly perfect state of preservation. It would be no exaggeration to affirm that it is the largest nearly entire fish which rocks of Carboniferous age have yet yielded.

Appended are a few localities in the Calciferous Sandstone Series of the district where *Rhizodus* remains have been discovered: Brickworks at Straiton; Oakbank, near Mid Calder; Burdiehouse; Arthur's Seat; Gowan's new quarry near Juniper Green, on the horizon of the Wardie Shales. It was found by Mr. Henderson at this locality in sandstone, an unusual circumstance.

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[1] The History of Rutherglen and East Kilbride, Glasgow, 1793, pl. xix. fig. 4.

[2] Trans. Royal Soc. of Edinb. vol. xiii. 1836, p. 169, *et seq.*

[3] Brit. Pal. Fossils, 1855, p. 612.

[4] Trans. Geol. Soc. Glasgow, 1865, vol. ii. p. 38, *et seq.*

[5] Quart. Journ. Geol. Soc. vol. xxii. 1866, p. 596, *et seq.*

[6] Quart. Journ. Geol. Soc. 1875, No. 124, p. 624, *et seq.*

[7] Pal. Ohio, *passim;* Pal. Illinois, *passim*; etc.

VII.—ON STRIATED PEBBLES FROM THE TRIASSIC CONGLOMERATE NEAR PORTSKEWET, MONMOUTH.

By W. J. SOLLAS, M.A., F.R.S.E., F.G.S.;
Professor of Geology in University College, Bristol.

DURING a recent visit to the tunnel now in course of construction beneath the Severn, I was taken by my friend Mr. Evan Jones, of University College, to examine a heap of Triassic pebbles and conglomerate, which had been exploited from the bottom of one of the shafts of the tunnel on the Portskewet side of the river. My attention was at once arrested by the striated and polished surfaces presented by many of the pebbles, and the results of the short examination I was able to make of them are embodied in the following note.

The pebbles are of all sizes, up to a foot or more in diameter, and they are well rounded at the edges and corners. Though they have evidently been derived from the adjacent Mountain Limestone, they break with a finely granular fracture like compact grit, owing no doubt to a crystalline structure superinduced by dolomitization. The matrix in which they were imbedded is a dolomitic paste containing numerous grains of quartz sand; it is coloured red with iron peroxide, which also colours the surface of the imbedded pebbles.

The smoothed surface of many of the pebbles is abundantly striated, especially on and around the edges and corners; the striæ commence as exceedingly delicate fine lines, which frequently deepen and widen in their course, till they terminate abruptly, so as to present the form of a half cone; at the deep end of the trough (base of the cone) a grain of quartz sand is sometimes found imbedded. Sometimes however the striæ are mere scratches thinning out at each end; they are not always straight, but sometimes curved, a whole group of parallel striæ being occasionally abruptly flexed to one side and then back again into their original direction. Now and then a furrow as much as a quarter of an inch wide may be observed, its sides being scored with delicate parallel striæ.

The presence of quartz grains in the matrix about the pebbles may be connected with their striation, and when a quartz grain is found imbedded at one end of a scratch, it may fairly be regarded as the instrument by which the scratch was produced. But to have produced the scratch it must have been (1) pressed against the surface, and (2) drawn along it. That the pebbles were pressed against each other, and thus exerted pressure on the sand grains lying between them, is shown by the fact that some of the smaller pebbles are sunk some distance into the larger, as though they had been pressed into a yielding substance. Nothing but great and long-continued pressure could have brought about this result.[1]

The cause of this pressure is to be found in the thick deposits of sediment which once rested upon the pebble beds. But a vertical pressure acting on an accumulation of loose pebbles would be resolved not only in directions normal to the touching-surfaces of

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[1] Sorby, Cardiff Nat. Soc. Trans. vol. v.

the pebbles, but also in others, leading to movements along lines of least resistance, by which the pebbles would become packed as closely as possible together. The quartz grains lying between the pebbles would then not only be pressed against, but also dragged over them. As they began to move, they would produce a delicate almost imperceptible striation, but with continued progress this would deepen, the grit would "bite" more deeply into the stone, and would at length become too far imbedded to overcome the resistance in front; then it would be brought to a sudden standstill, and remain as we now find it implanted at the end of the trough which it has excavated.

The history of the pebbles is then as follows: the Carboniferous Limestone, which crops up close to Portskewet around Chepstow, was denuded in Triassic times, and furnished material for a beach of rounded and polished pebbles on the shores of the Triassic sea; subsequent deposits, probably including Jurassic and Cretaceous sediments, were superimposed upon this beach, and under the considerable pressure which resulted the pebbles were packed closely together, forced one into the other, and pitted all over with imbedded sand grains; lateral movements dragged along the sand grains over the surfaces of the pebbles, scoring them with delicate furrows and striæ. Subsequently the dolomitic paste between the pebbles cemented into a hard matrix, and bound the whole together into a conglomerate.

In a note read before the British Association last August, I showed that certain fragments of limestone in a Triassic breccia retained the striation (slickenside) that had been impressed upon them before they were detached from the parent rock and deposited in their present place. We now find an instance of a contrary kind, in which the striæ on imbedded pebbles have been produced subsequent to deposition; but in neither case could an experienced observer be deceived for a moment as to the real nature of the striation; glacial action is here indeed altogether out of the question. It might be thought that the glacial origin assigned to the striations on certain fragments of stone from the Old Red Sandstone and Permian deposits, is called in question by these observations; the exact contrary is, however, the case; since while we have shown that striation may be produced on included fragments in other ways than by the action of ice, we have at the same time shown that no difficulty need be felt in distinguishing such striation when it occurs.

NOTICES OF MEMOIRS.

The Mont St. Gothard Tunnel.

Sulle condizione geologiche e termiche della grande galleria del S. Gottardo. Nota dell' inq. F. Giordano, Boll. del R. Comit. Geol. d'Italia. Sept. and Oct. 1880, Vol. XI.

IN the last Bolletino Inspector F. Giordano gives a lengthy report on the geological conditions of the St. Gothard tunnel, and many of the facts and particulars he tells us are drawn from the various published papers of the late chief engineer Stapff. Particulars are given as to the mode of excavation, and then the geological structure is considered. The rock section was found to be much the same as the preliminary investigations had indicated, consisting of granitoid gneiss, black schist, micaceous felsites with a small quantity of cipollino and other calcareous rocks in the large U folds under the Ursern and Ticino valleys. The fan structure, so general in all the Alpine ranges, was very marked, the strata spreading out in the St. Gothard mountain, and forming north and south the two U folds mentioned. It was in this northern fold under the Ursern valley that the greatest difficulties of the undertaking were met with, for the Ursern gneiss was found to be decomposed down to a very considerable depth, here over a thousand feet below the surface, so that the felspar had become a soft clay, and in consequence the expense was raised from about 3,500 or 4,000 up to 20,000 francs a mètre.

But the most interesting results of the undertaking are the observations made on the temperature of the air in the tunnel, together with comparisons of the temperature of the air and the earth at the surface. The figures of the temperature of the air are from observations taken in meteorological stations on the route, and in order to obtain the temperature of the earth at the surface, the temperature of the streams were measured and calculations were made from a large series of such observations.

The increase of temperature in the Mont Cenis tunnel was shown to be 1° Centigrade in each 51½ mètres below the surface, which increment was less than was expected from previous data, mostly obtained in mines and borings. The St. Gothard measurements give 1° C. in about each 52 mètres, thus both very closely correspond, considering that there are always modifying circumstances, as, for instance, decomposition of the rock where pyrites and other substances occur. The maximum temperature was 30·5° C. under 1700 mètres of rock, and the increase of temperature is shown to vary approximately with the profile of the mountain mass above, though somewhat modified by the surrounding mountains.

A very interesting concluding chapter deals with the lessons which may be learnt from this gigantic enterprise, and as the health of the workmen has in this case been very seriously affected by the unfavourable condition of work, it is evident that means must be taken to improve the ventilation in any similar undertaking, and Giordano considers that the Belgian system of making the advance gallery at the top gives less satisfactory results in this respect than the English system, where the preliminary gallery is at the base of the future tunnel, and as at present tunnels are proposed both through the Simplon and Mont Blanc, these questions have a practical importance.

The Simplon tunnel, according to one plan, would pass under a superincumbent mass of 2250 mètres, and this, according to the law now formulated regarding the increase of temperature, would give 47° C. in the middle of the tunnel; according to another proposition the tunnel would be at a greater altitude, and would give a temperature of 40° C. In the proposed Mont Blanc tunnel, however, the mountain mass would be greater than in either of the Simplon routes, and the temperature even higher. M. Dubois-Reymond has said that work under such circumstances would be impossible in a dry temperature of more than 50° C., or in a moist one of over 40° C., but Herr Stapff considers that some of the deep mines show that this is below the mark, but, however, points out the great difficulties that would accompany any such undertaking where there are a large number of workmen, even were no animals used, and even with every precaution taken in accordance with the experience now gained.

A good coloured geological section, together with a comparative diagram of the temperature, accompanies the paper. A. W. W.

REVIEWS.

I.—The Coal-fields of Great Britain; their History, Structure and Resources. With Descriptions of the Coal-fields of our Indian and Colonial Empire, and other Parts of the World. By Edward Hull, M.A., LL.D., F.R.S., etc. 8vo. 4th edition. (London, 1881: Edward Stanford, 55, Charing Cross.)

An important addition to the literature of our Coal-bearing rocks has just appeared in the fourth edition of Prof. Hull's work on "The Coal-fields of Great Britain." Few books have had so great a success, or of which new editions have been called for so rapidly. The third, embodying the Reports of the Royal Coal Commission, was published in 1873, and now in little less than eight years we are presented with the fourth. Portions of the work have been largely re-written, a new frontispiece representing characteristic plants of the Coal period, and three woodcut sections have been added. The latter include sections across the Castle Comer and Tyrone Coal-fields respectively, and a section through the London basin.

The chapter devoted, in the last edition, to the consideration of the Animal and Vegetable remains of the Coal period has been split up: the latter portion is entirely new, having been drawn up by Prof. Williamson, F.R.S.

As might have been expected, the stratigraphical classification has been modified to meet the more recently enunciated views on this subject as expressed by Prof. Hull in the Quarterly Journal of the Geological Society, for 1877.

The statistical portions of the work have been brought down to the date of 1878, whilst the highly important question of quantities, both wrought and unwrought, has been re-considered. The results given in the present volume naturally differ considerably from those stated in the last edition, allowing for the output during the interval between the appearance of the two volumes. In several instances Prof. Hull bows to the decision of the late Coal Commission in this matter, always, however, with the reservation, that seams of

Coal below two feet in thickness should not be calculated in estimating our future Coal resources. In this we agree with Mr. Hull.

The presumable quantity of Coal yet to be worked in Great Britain and Ireland, after necessary deductions, and at a depth not exceeding 4000 feet, is

In visible Coal-fields	79,752,000,000
In concealed Coal-measures	56,273,000,000
Total tons	136,025,000,000

"a supply," adds Prof. Hull, "which, if drawn upon at the rate of one hundred and thirty millions of tons, the quantity of 1878, would be sufficient to last for more than a thousand years."

The annual production of Coal over the whole globe is now said to be two hundred and eighty-nine millions of tons per annum. Under this heading the quantities have been brought up to dates varying from 1873 to 1879 for the various countries. During the past four years (1876–1879) the increase in output in our own country has been practically stationary. That for 1879 amounted to 134,008,228 million tons. In the chapter on concealed Coal-fields an account of the recent important borings in the S.E. of England has been added, especially those of the London area. Prof. Hull considers that, "we must look to tracts lying south of the Thames Valley as the *possible* area of concealed coal-fields," in the South-east of England, and especially, as Mr. Godwin-Austen has pointed out, along the margin of the North Downs, and the borders of the Wealden area.

We are glad to see that Prof. Hull, where practicable, devotes a few pages to the organic remains of the various Coal-fields under description. The occurrence of marine bands of fossils is always strongly dwelt on, and plays an important part in the classification adopted throughout the work. As a remarkable instance of the persistence of a calcareous stratum over large areas, is cited the *Spirorbis* limestone of the Upper Coal-measures, which can be traced in the same position throughout the Coal-fields of Coalbrook Dale, and Forest of Wyre southward, through Lancashire northward, and Warwickshire eastward, representing an area of about 10,000 square miles, and is only on an average about one foot in thickness.

The descriptive portions of the various Coal-fields have not been greatly altered, or added to, and remain nearly the same as in the last edition, excepting, of course, the information relating to quantities won and still to be wrought.

In the chapter devoted to the Coal-fields of Europe, a useful table is introduced, showing the corresponding groups throughout the British Islands and the various Continental Coal-basins. It appears that the uppermost division of the Coal-measures is usually absent from the latter. In the South Staffordshire Coal-field the great ten-yard, or "Thick Coal," has been either worked out, drowned, or destroyed to such an extent that probably little more than one-tenth remains to be won. Professor Hull wisely suggests that the coal proprietors of the district should combine to unwater this large area.

The general succession of the Carboniferous Series in Scotland has been modified to meet the author's latest views on Carboniferous classification, or more properly into four groups, instead of three, as in England. These do not correspond in every way with the subdivisions adopted by the Geological Survey of Scotland. We cannot help thinking some further useful details might have been gleaned about the Scotch Coal-fields from some of the more recently published "Explanations of Maps" of the latter body. The available Coal in Scotland for future use is estimated at about 9,643,000,000 tons.

In Ireland, the Antrim Coal Series is now assigned by Prof. Hull to the position of the Lower Coal and Ironstone Group of Scotland (= Edge Coal Series, or Middle Carboniferous Limestone Group of the Geological Survey), and the Yoredale Series of the North of England.

The account of the Indian Coal-beds has been completely revised. The age, following the views of Messrs. Medlicott and Blanford, is now stated to range from the Permian to the Upper Jurassic. There are thirty-seven separate fields, of which five only are regularly worked.

The information concerning the Australian Coal-fields is hardly up to date, and might advantageously be increased now that such a large mass of information has been brought together relating to the productive beds of New South Wales, and the unproductive strata of Victoria. We are, however, very glad to see that the views of the late Rev. W. B. Clarke have been more closely followed in this work than those of others who have written on the subject, although less conversant with it.

In the account of the African and Canadian Coal-seams, Professor Hull has availed himself of recent Reports and Surveys.

We must, in conclusion, congratulate the author upon having again brought his useful and important task to a most successful termination. We shall look forward, in the future, to the appearance of another and enlarged edition, with even greater feelings of pleasure than the perusal of the fourth has afforded us. As before, the work is published by Mr. Ed. Stanford, and everything appears to have been done to render it as complete and accurate as possible.

II.—ISLAND LIFE; OR, THE PHENOMENA AND CAUSES OF INSULAR FAUNAS AND FLORAS, INCLUDING A REVISION AND ATTEMPTED SOLUTION OF THE PROBLEM OF GEOLOGICAL CLIMATES. BY ALFRED RUSSEL WALLACE. (Macmillan & Co.; 1880.)

THE author desires this volume to be regarded not only as a popular supplement to his *Geographical Distribution of Animals*, but as a work complete in itself. He considers that the treatment of the subject has been placed on a sounder basis owing to the establishment of a number of preliminary doctrines, of which the most important are those "which establish and define (1) the former wide extension of all groups now discontinuous, as being the necessary result of Evolution; (2) the permanence of the great features of the distribution of land and water on the earth's surface; and (3) the nature and frequency of climatal changes throughout geological time."

Thus it will be perceived that this work, though dealing in the main with biological questions, enters to a considerable extent into physical ones, and has therefore a double claim to the notice of geologists, who will be anxious to know whether the author succeeds in establishing the three preliminary doctrines detailed above, and how far they assist him in clearing up the many anomalies of Island Life.

The first part of the book is occupied with the phenomena, laws, and causes of the *dispersal of organisms,* wherein the author discusses the general features presented by animal distribution, as well as the changes which have been the most important agents in bringing about the present condition of the organic world. In the second part he proceeds to apply the principles previously enunciated in the elucidation of the phenomena appertaining to *Insular Faunas and Floras.*

Part I.—The first five chapters deal mainly with the zoological aspects of distribution. Amongst the elementary facts some remarkable instances of discontinuity even on continents are detailed, and it is observed that such "numerous examples of discontinuous genera and families form an important section of the facts of animal dispersal which any true theory must account for." We may feel sure that the question of Evolution as the key to Distribution is ably stated by a naturalist who shares with Darwin the honour of having established the most important principles as to the origin and development of species and genera. The tendency to change, always more or less inherent, though stimulated and taken advantage of by circumstances, in combination with the powers of dispersal of organisms under different conditions, may serve to explain much of the existing distribution of plants and animals. In concluding this part of the subject, the author observes that the theory of Evolution necessitates the former existence of a whole series of extinct genera to fill up the gap between the isolated genera which in many cases now alone exist, while it is almost an axiom of natural selection, that such numerous forms of one type could only have been developed in a wide area and under varied conditions implying a great lapse of time.

Thus far, Mr. Wallace has been on his own ground, and there are few palæontologists at this time of day who are not more or less convinced of the truth of the first of his three great principles or doctrines. But when, in dealing with geographical and geological changes, he arrives at the consideration of the second principle, viz. the permanence of continents, there is by no means that unanimity amongst the authorities which the statement in the preface might lead the public to suppose. Geologists, especially in England, cling to the views of the great fathers of their science, and thus the opinions of Lyell and others as to a complete change of land and sea having taken place over and over again are, as he admits in Chapter VI., very generally held. Nor are these views confined to such speculations as those of a late President of the Geological Society of Liverpool. They are still held, to a certain extent, by no less an authority than Professor Huxley, who writes (*Nature*, Nov. 4, 1880): "There is nothing, so far as I am aware, in the biological or geological evidence at present accessible, to render untenable the hypothesis that an area of the mid-Atlantic or Pacific sea-bed as big as Europe should have been upheaved as high as Mont Blanc, and have subsided again, any time since the Palæozoic epoch, if there were any grounds for entertaining it." Thus the believers in the possibility of an Atlantis, notwithstanding the severity of our author's remarks (p. 398), may take comfort in the fact that Prof. Huxley deems such a thing possible, though he does not say that the event ever took place. The business of geologists is not so much to speculate on possibilities as to weigh the available evidence, and nothing can be clearer than the fact that the Jurassic, Lower Cretaceous, and Tertiary deposits, in our own country at least, are more or less of a shallow water or marginal character; but when Prof. Huxley, some three-and-twenty years ago, spoke of Atlantic mud as "modern chalk," the converse of this proposition was immediately taken for granted, viz. that the chalk must have been an abyssal deposit. Thus this latter supposition strongly favoured the then prevailing doctrine of the secular interchangeability of the great land and water areas. To combat this notion the author devotes several pages, and he certainly has the authority of Sir Wyville Thompson in support of his introductory statement, "That few of the rocks known to geologists correspond exactly to the deposits now forming at the bottom of our great oceans."

Still, the origin of chalk is a great puzzle, and some of Mr. Wallace's statements are likely to lead to much discussion. Sometimes, indeed, he seems to advance arguments against his own hypotheses, as, for instance, when he claims for his great central sea the depth of a few thousand feet, and immediately quotes S. P. Woodward to the effect that Ammonites, etc., were limited to depths not exceeding 180 feet. We are far from saying, however, that even these statements are essentially irreconcilable. There are large vertical regions of the chalk singularly free from Cephalopoda, and though, perhaps, not much of the sea in which chalk was deposited ever attained a depth of a few thousand feet, yet a depth of several hundreds—say even a thousand—might be sufficient to prevent the accumulation of any notable quantity of Ammonite remains.

The composition of chalk is also an enigma, for Foraminifera form only a small part of it. On the strength of the Faxoe beds in Denmark being highly coralline, he observes, "We have a clear indication of the source whence the white calcareous mud was derived which forms the basis of chalk." This is a bold assumption. In the first place, there are no regular reef-builders at Faxoe, the principal species being a *Caryophyllia*. Secondly, Lyell (Tr. Geol. Soc. vol. v. p. 248) expressly says, "There are patches of coral cemented together by white chalk, but with these exceptions no portion of our Oolitic rocks can less resemble ordinary chalk than the stone of Faxoe." We may add that the undoubted coral muds which have gone to form many of our Jurassic limestones yield a very different kind of rock to any variety of chalk known to us. Yet it must be admitted that Sorby, in his first address to the Geological Society in 1879, says, "that very many of the minute granules (of chalk) are identical in appearance with those derived from aragonite shells and corals," and he further observes that, though the more or less entire shells of Foraminifera form an important constituent, "yet that other larger calcareous organisms have probably yielded the greater part of the rock." When we quit the basin of the North Sea for that of the S.W. of France, the evidence for coral life is stronger, and the abundance of *Hippurites*, a relative of the reef-dwelling *Chama*, also points in this direction.

Whatever has been the origin of the composition of the peculiar rock known as chalk, the fairest inference seems to be that the conditions which produced it, in this country at least, were pelagic, though by no means oceanic, and hence its existence gives no colour to the notion of a great interchange of continent and ocean. Sir Wyville Thompson is quite in accord with the author on this point when he says (*Nature*, Nov. 1880), "The Chalk of the Cretaceous period was not laid down in what we now consider deep water, and its fauna, consisting mainly of shallow water forms, merely touches the upper limit of the abyssal fauna." Prof. Geikie (quoted at p. 94) is practically of the same opinion, when he says that during the Cretaceous period "the Atlantic sent its waters across the whole of Europe and into Asia, but they were probably nowhere more than a few hundred feet deep." Unfortunately, in thus ignoring the existence at this period of the Scandinavian and other highlands of Old Europe, Prof. Geikie gives colour, perhaps unintentionally, to the notion that the leading features of continents are less permanent than the theory adopted by the author would lead us to suppose.

This doctrine, viz. the permanence of continents and oceans, he considers lies at the root of all our inquiries into the past changes of the earth and its inhabitants, and it receives strong confirmation from the evidence adduced by Darwin, who has observed that hardly one truly oceanic island has been known to afford a trace of any Palæozoic or Mesozoic formation, so that they have not preserved any fragment of the supposed ancient continents, nor of the deposits which must have resulted from their denudation.[1]

Thirdly, the author discusses the changes of climate which have influenced the dispersal of organisms, and this leads him to the subject of glacial epochs and their causes, to which he devotes three chapters. Those readers who are anxious to arrive at the gist of the work, viz. the phenomena of insular life, will perhaps regret that so much space has been devoted to this class of speculation, and some might even think that with a concise summary of conclusions in the text, the rest of the matter might have been relegated to an appendix, or reserved for a separate work. But these subjects are

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[1] See ante, p. 75, "Oceanic Islands," by T. M. Reade, F.G.S.

undoubtedly popular—they appeal so powerfully to the imagination,—and may in a certain sense enhance the value of the volume. The last chapter of Part I. discusses the earth's age, and the rate of development of animals and plants.

Part II.—When the difficulties presented by the peculiarities of island life are mastered, Mr. Wallace is of opinion that we shall find it comparatively easy to deal with the less clearly defined problems of continental distribution. Hence the importance of the subject. Islands have had two distinct modes of origin, and the difference is fundamental. They are *oceanic* or *continental.* Darwin has shown that with very few exceptions all the remoter islands of the great ocean are of volcanic or of coralline formation, and that none of them contained indigenous mammalia or amphibia. Continental islands are more varied in their geological formation, and may be divided into two groups—ancient and recent. Islands of an anomalous character constitute a fourth section.

Amongst the *Oceanic Islands* are the Azores, Bermuda, the Galapagos, St. Helena, and the Sandwich Islands. Amongst the *recent continental islands* are the British Islands, Borneo and Java, and Japan and Formosa. Madagascar is an example of the type of *ancient continental islands,* whilst Celebes and New Zealand figure in the exhaustive division.

It would clearly be impossible within the limits of a review to give even a sketch of all these chapters, each of which is a little treatise of itself, full of the best information in that branch of natural history which is connected with the geographical distribution of animals and plants. A sample of the mode of treatment of each of the three principal sections must suffice.

1. *Oceanic Islands.*—The Azores, which bear the same relation to Europe that the Bermudas do to America, lie in the course of the south-westerly return trades, and also of the Gulf-stream. They are 900 miles from the coast of Portugal, with a maximum depth of 2,500 fathoms intervening, and are destitute of all terrestrial indigenous vertebrata. To the oceanic type they present a single exception, in that one of the islands contains a small deposit of Miocene age. Thus the group may be of considerable antiquity, but the fauna, "at all events as regards the birds, had its origin since the date of the last glacial epoch." The small amount of differentiation which time has effected in the birds—a bullfinch being the only speciality—is one of the principal reasons for this belief in the recent origin of the fauna, but the explanation to which Mr. Wallace points is scarcely satisfactory. The glacial theory is a dangerous weapon even in the hands of the most experienced geologists, and draws quite as largely upon the unscientific imagination as Atlantis or Lemuria—those especial bugbears of the author. When, therefore, he would have us infer that all land birds were destroyed by the severity of glaciation in a group of islands situated as these are, and at the sea-level, we should at least expect him to indicate some undoubted evidences of ice action in the islands themselves, before consenting to entertain such a proposition.

Why not try submersion? He believes that a submersion to the extent of nearly 2,000 feet destroyed much of the life of the British Isles during the latter part of the Glacial epoch. And if a steady-going continental island like Britain, with a pedigree of rocks equal to any in the world, should have thus suffered, why not a volcanic accumulation in mid-ocean, presumably unstable by reason of its composition? It is true that Pico is 7,000 feet above the sea, though this is very exceptional.

But the submersion of an oceanic island is inconvenient, as this might favour the notion of Atlantis. The zoological reasoning is, as usual, admirable throughout the chapter.

2. *Recent continental islands.*—"Great Britain is perhaps the most typical example of a large and recent continental island now to be found on the globe." All geologists are aware that the British Islands rest upon the 100-fathom platform, which extends in a sweep from the coast of Jutland round by Shetland and Ireland to the south-west of France, and that a rise of less than half this depth would join England to the continent. Mr. Wallace goes into the question of the direct evidence that exists of this recent union, especially quoting the cases of the well-known submerged forests in Cornwall, Devon and the Bristol Channel. Certainly the forest-bed of Cromer, in Norfolk, also mentioned by him in this connexion (p. 317), belongs to quite a different category, as this is a pre-glacial forest bed, almost Pliocene in its character, and can afford very little proof of our latest union with the continent, which "geologists are all agreed was subsequent to the greatest development of the ice, but probably before the cold epoch had wholly passed away." The buried river channels in Scotland, far below the present sea-level, and the discovery of fresh-water and littoral shells at considerable depths off our coasts, are additional proofs of former elevation. On the other hand, the well-known phenomena of Moel Tryfaen, and elsewhere, are indications of a submergence which is, the author states, in no small degree, the cause why our islands are so poor in species, since sufficient time had not elapsed for immigration to have been completed "before the influx of purely terrestrial animals was again cut off." This would seem to imply also that the communication might not have been very wide.

Amongst the higher animals no more than three species—all birds—can be said to be peculiar, and, whilst Germany has ninety species of land mammalia, Great Britain has forty, and Ireland twenty-two. Possibly the respective areas of the three countries may have something to do with this, but the same cannot be said of the more slowly moving reptiles and amphibia, since Belgium has twenty-two species and Ireland only four. We are much better off in freshwater fishes, there being no less than fifteen peculiar, of which ten are species of trout and charr restricted to certain lakes in the British Isles. These local modifications are due to restricted intercourse, and the result is the same as with the life of Oceanic islands. The remainder of this chapter (xvi.) deals with the insects, land and fresh water shells and flora, and is full of highly interesting matter.

3. *Ancient continental islands.*—The extraordinary complexity of the organic relations of Madagascar, says Mr. Wallace, is due, partly to its having received its animal forms from two distinct sources, but mainly to its having been separated from a continent now zoologically in a different condition. The facts and reasonings of this important chapter, though in the main zoological, have a distinct geological bearing. Madagascar has not the characteristic animals of either Africa or Asia. Half the existing species consist of Lemurs. In fact, the island is a sort of Zoological Garden of high antiquity, free from the ravages of the large Carnivora, where decaying groups of creatures, which have elsewhere perished or become scarce, maintain a comparatively secluded existence.

Why is this so? When Madagascar was united to Africa, from which it is at present separated by waters of considerable depth, the adjacent continent was then entirely severed from Arctogæa by the nummulitic sea, and constituted a sort of Australia, poor in the higher forms of life. The upheaval of this sea-bed in Miocene times admitted the higher types of mammalia, which were developed in the great Euro-Asiatic continent, to the mainland of Africa, but Madagascar had then become an island, and the great beasts were thus excluded from it. We know from the rich deposits of fossil mammals in the Miocene beds of Europe and N.W. India that the great African mammals inhabited those regions.

These reasonings tend to explain the absence of certain forms; we must next consider the origin of the existing groups. Doubtless Madagascar, through the mainland of Africa, had an earlier union with Arctogæa, though it is rather a strong assumption that, otherwise, it could never have obtained any mammalia (p. 391). However, the Lemurs, Insectivores, and Civets are known to have inhabited Europe during the Eocene and Miocene periods, and thus a certain geographical link is established between the ends of groups now wide asunder. The dispersal of these groups, superinduced by changes of surface and climate, throughout long ages of geological time, may thus serve to render possible an explanation of such an extreme case as that of the insectivorous *Centetidæ*, now confined to Madagascar and the West Indies.

The question whether the birds of Madagascar require the adoption of the hypothetical Lemuria is scarcely one to be discussed in the GEOLOGICAL MAGAZINE. There are about one hundred and five land birds, all but four or five being peculiar. When we consider that the Azores, more than thrice as far from the mainland, contain but one bird peculiar to them, and bear in mind also that the author regards their whole avifauna as the result of recent immigration, voluntary or involuntary, we can only express surprise at the unenterprising character of the birds of East Africa, who do not care to cross the Mozambique channel, though the Comoro Islands offer a series of convenient halting-places.

The chapters on New Zealand, and on the Arctic element in South Temperate Floras, complete the details of Island Life—a work which is certain to be extensively read, and which is full of instructive matter. We recognize throughout the vigorous original touches of the accomplished biologist, and if, in his treatment of some of the problems of speculative geology, the results seem not quite so satisfactory, the faults, if there be any, are perhaps less with the author than in the nature of the subject.

The volume is well got up, and usefully illustrated with maps throughout. W. H. H.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—Dec. 15, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Constitution and History of Grits and Sandstones." By John Arthur Phillips, Esq., F.G.S.

In the first part of this paper the author described the microscopic and chemical structure of a large series of grits, sandstones, and, in some cases, quartzites, of various geological ages, noticing finally several sands of more or less recent date. The cementing material in the harder varieties is commonly, to a large extent, siliceous. The grains vary considerably in form and in the nature of their inclosures, cavities of various kinds and minute crystals of schorl or rutile not being rare. The author drew attention to the evidence of the deposition of secondary quartz upon the original grains, so as to continue its crystal structure, which sometimes exhibits externally a crystal form. This is frequently observable in sandstone of Carboniferous, Permian, and Triassic age. Felspar grains are not unfrequently present, with scales of mica and minute chlorite and epidote. Chemical analyses of some varieties were also given. The author then considered the effect of flowing water upon transported particles of sand or gravel. It results from his investigations that fragments of quartz or schorl less than $\frac{1}{50}''$ in diameter retain their angularity for a very long period indeed, remaining, under ordinary circumstances, unrounded; but they are much more rapidly rounded by the action of wind. It is thus probable that rounded grains of this kind in some of the older rocks, as, for example, certain of the Triassic sandstones, may be the result of Æolian action.

2. "On a New Species of *Trigonia* from the Purbeck Beds of the Vale of Wardour." By R. Etheridge, Esq., F.R.S., President. With a Note on the Stratigraphical Position of the Fossil by the Rev. W. R. Andrews.

In this paper the author described a species of *Trigonia* discovered by the Rev. W. R. Andrews in the "Cinder-bed" of the Middle Purbeck series in the Vale of Wardour. The specimens were found in the railway-cutting one mile west of Dinton station. The shell was referred to D'Orbigny's section "Glabræ" of the genus *Trigonia*, and named *Trigonia densinoda.* In its ornamentation it closely resembles *T. tenuitexta*, Lyc., of the Portland Oolite; but is more depressed and lengthened posteriorly, and destitute of the antecarinal space which occurs in all known Jurassic "Glabræ." The escutcheon is remarkably large and possesses transverse rugæ, as in the Neocomian "Quadratæ." The author regarded the species as a transition form connecting the two groups of *Trigoniæ* above mentioned. The description of the new species was accompanied by a note on the Purbeck strata of the Vale of Wardour by the Rev. W. R. Andrews.

II.—Jan. 5, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read :—

1. "The Archæan Geology of Anglesey." By C. Callaway, Esq., M.A., D.Sc., F.G.S. With a Note on the Microscopic Structure of some of the Rocks, by Prof. T. G. Bonney, M.A., F.R.S., Sec.G.S.

The author discussed the stratigraphy and lithological characters of the rocks in the following areas:—The border of the Menai Strait, the Llangefni region, and the central zone, about Bodafon, Llangwyllog, Llanerchymedd, and Paris Mountain, which, he considers, establish the following conclusions :—(1) that in Anglesey there are two Archæan groups, the slaty and the gneissic; (2) the slaty is composed of slates, shales, limestones, grits, conglomerates, and chloritic schists, in which at present a definite order has not been ascertained. The gneissic group is composed of the following, in *descending* order—granitoidite, chloritic and hornblendic schists, grey gneiss, quartz-schist, and hälleflinta; (3) the slaty series is occasionally foliated, but is usually in a partially altered state; the gneissic group is thoroughly metamorphosed; (4) the slaty series has closer lithological affinities with the St. Davids volcanic group, the Charnwood rocks and the Lilleshall series than with the Bangor group; (5) the slaty series is undoubtedly Pebidian, the gneissic series may, with some probability, be referred to the Dimetian. The microscopic structure of the principal varieties of the rocks mentioned in the above paper was described by Prof. Bonney.

2. "The Limestone of Durness and Assynt." By C. Callaway, Esq., D.Sc., F.G.S.

This paper gave the result of an examination of the vicinity of Durness and Inchnadamf, where Lower Silurian fossils occur in a limestone, as discovered by Mr. C. Peach. At Durness the only evidence of the limestone underlying the schist is the asserted fact of the dip being in the same direction; for all admit the junction to be a faulted one. The author showed that while the flaggy (upper) schists dip uniformly to N.E., the limestone dips in a very variable manner E.S.E., E., and but rarely N.E., any dip N. of E. being exceptional, and then only at a distance from the schist. Again, the Smoo mass of limestone, cut off from the Durness area by a faulted strip of gneiss, dips either E.S.E., or even more to S. After discussing the relation of the quartzite and gneisses, the author passed to the Assynt district, and pointed out that the relations of the limestone and the quartzite are by no means satisfactorily established, that their conformity is rendered dubious by a marked discordance of strike, and that the limestone lies in a synclinal basin, so that its dip in one place is in the opposite direction to that of the quartzite. From the above considerations the author holds that in these districts there is no proof of the Lower Silurian age of the quartzite and newer series of flaggy gneiss and schist.

3. "On a Boulder of Hornblende-Pikrite near Pen-y-Carnisiog, Anglesey." By Prof. T. G. Bonney, M.A., F.R.S., Sec.G.S.

The boulder described had been originally about a cubic yard in volume, and the fragments lay in a field left of the road from Pen-y-Carnisiog to Bwlyn. The ground-mass consists of hornblende and serpentinous products with a little mica. In this are crystals, often $\frac{2}{3}$ inch long, of brown hornblende with inclosures of altered olivine. The author doubted whether this hornblende is not a paramorph after augite; some of that in the ground-mass is certainly of secondary origin. He compared the rock with a pikrite from the Lleyn peninsula, and two described by Prof. Geikie from Fifeshire. It differs from all these, but has a singular resemblance to a pikrite from Schriesheim (Odenwald), except that it is rather more altered. He called attention to the rock in hopes that some geologists may discover it *in situ*, as it will be of much value in deciding in what direction the ice has moved over Anglesey.

CORRESPONDENCE.

DISTURBANCES IN THE CHALK OF NORFOLK.

Sir,—In the "Annals and Magazine of Natural History," for October, 1880, is an interesting paper by Mr. Jukes-Browne on "The Chalk Bluffs of Trimmingham," wherein, after noting the opinions of various writers concerning their origin and history, he expresses his own conviction that they are outlying rocks or needles formed previously to the deposition of the Pliocene (fluvio-marine) series of the Norfolk coast.

Mr. Jukes-Browne justly compares the disturbances in the chalk at Trimmingham with those at Whitlingham and Swainsthorpe, brought into notice by Mr. J. E. Taylor (Geol. Mag. Vol. II. p. 324; Vol. III. p. 44), and endeavours to support his own view of the date of the Trimmingham disturbance by reference to Mr. Taylor's statement that the Chalk at Whitlingham was disarranged before the formation of the Norwich Crag. In a more recent paper by Mr. Taylor (Geol. Mag. Vol. VI. p. 509) the author, however, attributes the twisting and dragging up of the Chalk and its flint-layers to the agent which formed the Upper or Chalky Boulder-clay. This view I entirely coincide with, and during my Geological Survey-work near Norwich I obtained conclusive evidence that the similar disturbance at Trowse was due to glacial action (Geol. Mag. Dec. II. Vol. VI. p. 380). I differ only from Mr. Taylor in assigning the formation of this Boulder-clay to the direct agency of land-ice, whereas he inclines to the view that the Upper Boulder-clay was formed under glacial-marine conditions, and that the stranding of ice-bergs would account for the disturbances of the Chalk. There is much to be said on both sides of the question; my object, however, in writing this, was not to discuss the origin of the Chalky Boulder-clay, but to point out that the more remarkable disturbances in the Chalk near Norwich are of glacial origin, and subsequent to the deposition of the Norwich Crag. The section at Litcham, described by Mr. S. V. Wood, jun., tells the same story; and having visited the Bluffs at Trimmingham on many occasions with my colleague, Mr. Clement Reid, I have been led to adopt his explanation that the disturbances of the Chalk there were produced by land-ice.

Fakenham. Horace B. Woodward.

THE PRE-CAMBRIAN ROCKS OF BRITAIN AND BOHEMIA.

Sir,—In Mr. Marr's valuable paper *On the Pre-Devonian Rocks of Bohemia*, published in the last number of the Geological Society's Journal, there is one point on which further evidence would seem desirable. I refer to his correlation of the Bohemian gneissic series with the St. David's Dimetian. He describes the Bohemian rocks as "gneiss," "gneissic rock . . . . interspersed with small garnets," "white foliated quartzose rock," "crystalline limestone . . . . . . strongly foliated, and containing silvery mica." Besides these rocks there is a "band of graphite" and dykes of "black eclogite." Having examined the Dimetian of St. David's from top to bottom, I did not find any one of the varieties named by Mr. Marr. The series is mainly composed of quartzite and granitoid rock, and the existence of foliation has not been proved in either the quartzose or the more felspathic types. I do not deny the Dimetian age of the Bohemian gneiss, but I should hesitate to accept the present evidence as decisive of the point. From Mr. Marr's description, the Pebidian age of étage *A* appears highly probable, and the discovery is of great interest. The two Pre-Cambrian groups in Bohemia are in their lithology not unlike the two Anglesey series, of which full descriptions will shortly be communicated to geologists. If the older Anglesey series could be definitely accepted as Dimetian, Mr. Marr's opinion would receive strong confirmation. C. Callaway.

Wellington, Salop, *Nov.* 30, 1880.

ON THE TUSCAN SERPENTINES.

Sir,—The author of the notice of Prof. Pantanelli's paper *I Diaspri della Toscana, etc.* (Geol. Mag., 1880, p. 564) inadvertently attributes to me an opinion which I do not hold, when he includes me among those who have recently maintained "that the (Tuscan) serpentines represented true submarine lavas of the Upper Eocene." On the contrary, in my paper (Vol. VI. p. 362) I am at some pains to show that these serpentines are intrusive in the diaspro, etc. The evidence against their being contemporaneous lava flows is strong. It is a remarkable thing that olivine rocks appear very rarely to reach the surface. I have never myself seen a serpentine which was not intrusive. Some picrites, however (*e.g.* that described by Professor Geikie in his paper on the Volcanic Rocks of the Firth of Forth), and limburgites appear to be lava flows, as may possibly be one or two other olivine rocks. T. G. Bonney.

ENTOMOSTRACA IN COAL-SHALES.

Sir,—In the black shale lying around the bases of some of the Sigillarian tree-stumps or stools, containing remains of small Amphibia (*Dendrerpeton*, etc.), and Land-shells (*Pupa*, etc.), at the South Joggins, Principal Dawson, of Montreal, has detected numerous specimens of Entomostraca.[1] Portions of this shale, forwarded for examination, have yielded to my friend Mr. J. W. Kirkby and myself several specimens of *Carbonia fabulina*, J. and K.,[2] mostly of the typical form, but some belong to the variety which we term *humilis*.[3] All of them have the surface of the valves either punctate or subreticulate. The muscle-spot is only indicated in one or two subtranslucent specimens. A single valve of a larger and relatively longer species is near to, if not identical with, our *Cythere* ? *bairdioides*.[4] Besides 1. *Carbonia fabulina,* with its var. *humilis,* and 2. *C.* ? *bairdioides*, there are present in this shale—3. Ganoid scales of Fishes; 4. very thin shells like *Anthracomya* (*Naiadites*); 5. *Spirorbis* (*carbonarius*, or near it); 6. bits of carbonized wood, showing structure; 7. Obscure Plant Remains, abundant.

T. Rupert Jones.

CERVUS MEGACEROS IN BERKSHIRE.

Sir,—Portions of the Antlers of two individuals of the Gigantic Irish Deer (*Cervus megaceros*) dug out of the Peat of the Kennet Valley, at Aldermaston, have been lately procured by my friend Mr. Walter Money, F.S.A., of Newbury, and will probably find a resting place in the Museum of the Oxford University. This authenticated find of *Cervus megaceros* in the Post-glacial or Quaternary alluvium of Berkshire will be of interest to some of your readers.

T. Rupert Jones.

PEBBLE FROM THE CAMBRIDGE GREENSAND.

Sir,—I notice that in your September Number Mr. Keeping calls attention to a pebble of the Wrekin devitrified pitchstone which was found in the Upper Neocomian deposit of Potton. It may be of interest to some of your readers to know that I found a pebble of a rather similar nature in the Cambridge Greensand near Horningsey, last June. It was a subangular fragment showing well-marked fluidal structure. Prof. Bonney kindly had a thin section cut for me, and examined it. He said, "It is a sort of devitrified pitchstone or rhyolite with well-marked fluidal structure; it is inclined to be spherulitic, and the nature is undoubted." He thinks, however, that it has not exactly the structure of the Wrekin pitchstones, but might possibly be matched either in Scotland or Norway.

Sidney College, Cambridge,
Nov. 14*th*, 1880.

W. W. Watts.

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[1] See the "American Journal of Science," vol. xx. November, 1880, p. 404.

[2] "Annals Nat. Hist." ser. 5, vol. iv. p. 31, pl. 2, figs. 1-10.

[3] *Ibid.* figs. 11-14.

[4] *Ibid.* p. 38, pl. 3, figs. 24-26.

PRESENTATION OF THE EDWARD WOOD COLLECTION TO THE YORK MUSEUM.

SIR,—The well-known collection of fossils formed by the late Mr. E. Wood, of Richmond, Yorkshire, has been purchased by Mr. Wm. Reed, F.G.S., of York, and by him presented to the Museum of the Yorkshire Philosophical Society, York.

The collection consists of about 10,000 specimens, and is specially rich in fossils from the Carboniferous rocks. W. KEEPING.

THE MUSEUM, YORK, *Jan.* 17*th*, 1881.

Mr. Reed had previously presented his own magnificent collection of fossils to the Yorkshire Philosophical Society.

MISCELLANEOUS.

A FOSSIL RHINOCEROS IN THE FLESH.—The body of a large Rhinoceros was recently discovered in the Werohojanksi district, Siberia. It was found on the bank of a small tributary to the Jana (Lena?) river, and was laid bare by the action of the water. It was remarkably well preserved, the skin being unbroken and covered with long hair. Unfortunately only the skull of this rare fossil has reached St. Petersburg, and a foot is said to be at Irkutsk, while the remainder was allowed to be washed away by the river soon after it had been discovered. The investigation of the skull shows that this Rhinoceros (*R. Merckii*) is a connecting form between the species now existing and the so-called *Rhinoceros tichorhinus,* remains of which are not unfrequently found in the Brick-earth of the Valley of the Thames at Ilford, and in Prussia.

THE Readers of this Magazine will be glad to learn that Mr. A. R. Wallace, the celebrated explorer, naturalist, and author, is to receive a pension of £200 a year from the Government, in recognition of his eminence in zoological science, in promoting which he has done so much good service.

We are requested by the author to print the subjoined list of Errata in Mr. H. H. Howorth's paper on "The Mammoth in Siberia," GEOL. MAG. Dec. 1880, pp. 550—561.

Page	551	*line*	29	*for*	Berislinor	*read*	Bereshnoi.
,,	,,	,,	,,	,,	Kolymak	,,	Kolymsk.
,,	,,	,,	40	,,	Kazahs	,,	Kazaks.
,,	,,	,,	48	,,	Alansk	,,	Alaseisk.
,,	552	,,	1	,,	Yerambei	,,	Yerumbei.
,,	554	,,	9	,,	48	,,	47.
,,	555	,,	22	,,	Hippopotamus	,,	Cave-lion.
,,	,,	,,	27	,,	Musk Ox	,,	Musk Sheep.
,,	556	,,	2	,,	reindeer, most,	,,	reindeer-moss.
,,	,,	,,	26	,,	Sselakim	,,	Sselakino.
,,	,,	*last line*		,,	188	,,	114.
,,	,,	,,	5 and 6	,,	delete the authority between parenthesis.		
,,	,,	,,	18	,,	north	,,	south.
,,	,,	,,	34 & 39	,,	Samukof	,,	Sannikof.
,,	,,	,,	,,	,,	Kililnoi	,,	Kotelnoi.
,,	,,	,,	46	,,	Erdmann	,,	Ermann.
,,	560	,,	2	,,	Yava,	,,	Yana.
,,	,,	,,	16	,,	Erdmann	,,	Ermann.
,,	,,	,,	18	,,	Indiger	,,	Indiga.
,,	,,	,,	23	,,	bushes	,,	trunks.
,,	,,	,,	35	,,	Awauka	,,	Awamka.
,,	,,	,,	42	,,	*Amare*	,,	*Limax.*
,,	,,	,,	,,	,,	*anabora*	,,	*anatina.*
,,	,,	,,	45	,,	Breschof	,,	Brjohof.
,,	,,	,,	50	,,	*id.* 86	,,	*id.* xi. 88.
,,	553, *l.* 23; 558, *l.* 23; 559, *l.* 3; 560, *ll.* 32 and 48, *for* Dudimo, *read* Dudino.						

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VIII.

No. III.—MARCH, 1881.

ORIGINAL ARTICLES.

I.—On the Connexion between Travelled Blocks in the Upper Punjab and a supposed Glacial Period in Upper India.

By A. B. Wynne, F.G.S., etc.

THE transported blocks of the Indus Valley are not without some interest in connexion with the theory of an Indian Glacial Period akin to that of Europe, and with regard to the support they do or do not give to that supposition.

I do not propose to enter into the whole question of this Glacial Period, one much affected by observations made in regions which I have not explored, but only intend to discuss facts within my knowledge concerning a district with which I am better acquainted.

The district is the Upper Punjab, the northern part of "the land of the five rivers," and is almost entirely included in the local portion of the basin of the largest of these, the Indus or *Abba Sin.*

From the last gorge of this great river, where it issues from the Himalayan Mountains, down to within a few miles of where it breaks through their furthest outworks in a southerly direction, a quantity of crystalline masses derived from the Himalayan ridges, and often of huge size up to 50 or 100 feet girth, are distributed for forty or fifty miles, chiefly on its left bank, and so far as twenty miles from the river itself. Similar blocks also occur locally along smaller tributaries of the Indus and of the Jhelum, which is one of its affluents, but these blocks are not known at any great distance from the hills.

The blocks in question were noticed many years ago in one of Dr. Verchere's papers,[1] and subsequently in the publications of the Geological Survey of India, where I have attributed their distribution to the agency of floating-ice; but my friend and colleague Mr. Theobald claims that they are additional evidence in support of his view that extensive glaciers once descended from the Himalayas and left their *detritus* on the plains of India at elevations of and under 2000 feet, where the climate has so much changed that snow is now never known to fall.

Mr. Theobald's last paper on the subject appears in the Geol. Surv.

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[1] A. S. Beng. 36. pt. 2.

Ind. Records, vol. xiii. pt. 4.[1] After referring to the distribution of the blocks which I have called "the Indus drift," he contends that they occur only on the surface of fluviatile deposits, and hence that they must form parts of lateral moraines or other glacially transported detritus, it would seem according to his view deposited from the melting both of solid glaciers and also of floating-ice. Where the limit between these two varieties of ice agency occurs he does not indicate, and it does not appear how his glaciers traversed the fluviatile deposits without disturbing them or sweeping them away.

It seems to be generally received that towards the close of the great Tertiary period in the Punjab, during which rocks to the thickness of some miles were deposited, and the successive stages of the elevation of the Himalayas took place, one of the last upheavals of these mountains occurred. It may also be considered highly probable that these earth-movements of the Himalaya were not always conterminous with the extent of the whole chain. However this may be, I have met with some evidence which may point to the possibility that the western or Punjab portion of the mountains was even so recently as during Post-Tertiary times much more elevated than it is at present.

On two of the outer ranges, at heights of many hundred feet above the Indus, near the summits of the Chita and Salt Ranges in the vicinity of this river, I have found either coarse river-like deposits or scattered irregularly-shaped and rounded dark or variously-coloured river-stones, consisting of precisely the same Himalayan rocks as are now being rolled southwards by the river through its gorges far below. Upon these facts I rested the supposition that the river channel was once situated at a height of something like a thousand or fifteen hundred feet above its present level,[2] in which case the neighbouring ranges of the Himalaya, as far as the sources of the river, might also have been much more lofty.

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[1] In this publication my colleague has scarcely given an accurate view of my statements or opinions. His suggestion that I thought the Indus had abandoned its deep rocky gorge at the Chita range since this was formed is not warranted by anything I have written. His view that stones from the bed of that river were carried up to villages on the summits of the range named, by their inhabitants for the purpose of decorating graves, had of course suggested itself to me, and been rejected for want of evidence that such villages or the graves of their inhabitants ever existed there. He classes me by implication as one of his Antiglacialists, because I have refrained from advocating his theory, for want of conclusive evidence. With these exceptions, and a few others of minor importance as to his limitation of the localities occupied by the travelled blocks, I only regret that the paper seems to prove nothing in support of the author's views as to the connexion between the blocks and glaciation at low levels in India.

[2] In the paper alluded to before, Mr. Theobald argues that the Indus did not cross the Chita Range at a higher level, because he failed to find its erratics (*i.e.* transported debris), caught in clefts between the limestone crags of the range. From his reference it would appear likely that he only crossed one or other of the low passes of the range by road, where the limited nature of his observations might lessen their force, if this were not entirely set aside by the fact that the mountain surface of that period must long since have been removed by denudation. The argument, however, was not that the river had wandered, but that it ran at a much higher level nearly at the same place.

Otherwise a slow elevation might be supposed to have taken place nearly at the same rate as the river cut its channel, or the result might be ascribed to the vast and continuous operation of aerial denudation, in reducing the altitude of the ground.

If either the first or the last of these suppositions be correct, the greater elevation of the mountains would bring the regions of glaciers and perennial snows under existing climatic conditions nearer to the area now covered by the transported blocks.

The Indus is famous for its debacles, and these, carrying in their rush fragments of glaciers laden with rock masses from the high regions into a lake (which there is reason to suppose once covered much of the Northern Punjab Steppe), it appears to me would account very simply for the transport southwards of the blocks referred to, and also for their distribution.

The lacustrine character of the silt or loess, extensively spread over the Rawul Pindi plateau, is in favour of the former existence of a lake or lakes in much the same relative position to the mountains as the Terai swamps at their foot further eastward, and in its waters the ice-floated blocks could have been impelled for some distance in the currents caused by floods.

As the natural consequence of the ordinary glaciers of the mountains approaching nearer to the plains, owing to greater altitude, traces of these glaciers might still be found in ice-borne blocks resting where glaciers no longer exist beyond the area occupied by the supposed lake or lakes. Where such blocks rested on softer material than themselves, sub-aerial denudation would reduce their stability till they might be rolled into the deepest *Khuds* and river-courses, as is the case along the Upper Indus, the Upper Jhelum in Kashmir territory, or along its tributary the Nainsuk from Kaghan.

It would thus appear that either within or beyond the area where floating-ice could move them, great transported rock fragments such as these could find their way into their present positions without the necessity for imagining that enormous glaciers spread in recent times from the Himalaya Mountains out over the plains of India, to elevations not more than 2000 feet (or even less) above the sea, or to distances of 40 or 50 miles away from these mountains—in the Upper Punjab.

To any one familiar with the appearance of the "Drift" of Ireland and the glacial features of many of its hill regions, the great difference between these features and the supposed glacier work in the Upper Punjab is so palpable, that the strongest possible doubts suggest themselves as to the probability of extensive glaciation at low levels in the north of India, and certainly when the circumstances urged in favour of this bear any other interpretation, the alternative supposition gathers force from the comparison.

II.—NOTES ON THE PHYSICAL CHARACTER AND THICKNESS OF THE UPPER SILURIAN ROCKS OF SHROPSHIRE, WITH THE BRACHIOPODA THEY CONTAIN GROUPED IN GEOLOGICAL HORIZONS.

By THOMAS DAVIDSON, F.R.S., and GEORGE MAW, F.G.S.

(*Continued from p.* 13.)

SHROPSHIRE was always considered by Sir Roderick Murchison as one of the districts in which his Upper Silurian rocks could be most advantageously studied.[1] We propose, therefore, in this communication to offer some few notes on the Geology and Palæontology of the Wenlock and Ludlow series; illustrated by the Brachiopoda, reserving for the present what we may have to communicate with respect to the Upper Llandovery.

The extensive washings undertaken by one of us have brought to light some fifty to sixty thousand specimens, of which some were previously unknown, while others were new to the district. The new species will be described and figured in the sequel.

The occurrence of cleanly-washed fossils in the debris remaining from many of the clays and shales suggested to one of us that the potter's process of lævigation might be conveniently employed by the geologist for the collection of fossils, especially of the smaller species, from the soft shales, in which hand-picking is at best a most laborious process.

The potter's object in clay lævigation is to get rid of the coarser matter. The fossil collector pursues, as it were, the process in reverse by getting rid of all the clay and fine matter, and obtaining in a compact form the coarse debris, including the organic remains.

A potter's "Blunging" or clay lævigating machine, though it greatly facilitates the process, and enables large quantities of material to be quickly lævigated, is not essential, as an experienced worker can in a day easily lævigate several hundredweights of clay or soft shale, with the aid only of a tub and a stout wooden stirrer.

The operator should provide himself with a set of sieves of the following mesh: 1, 2, 4, 6, 10 and 12 wires to the inch.

Having digested in water, say, half a ton of material, the "*slip*" or liquid clay is poured off through the No. 12 or finest sieve, which would catch any small fossils; and the remaining debris, which might weigh about a hundredweight, should be repeatedly washed with fresh water, by which all fine matter will be removed, and the material remaining will in most cases resemble clean coarse gravel, with which the operator will have further to deal. As this will

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[1] We follow Sir Roderick Murchison's classification of the Lower Palæozoic formations, for no geologist worked harder to unravel the complications under which the Upper and Lower Silurian rocks were shrouded. The publication of the "Silurian System" in 1839, with all its imperfections and on the model of Smith's "Strata identified by Organized Fossils," did more than any other work to stimulate researches in the right direction all over the world. See also Barrande's important paper "Du maintien de la nomenclature établie par Mr. Murchison," Congrès International de Géologie, p. 101, Paris, 1878.

ultimately be the subject of the laborious process of "hand-picking," it is desirable to reduce its bulk as much as possible. The whole is first passed through the sieve of one-inch mesh, which catches all the stones, lumps of undigested shale and the larger fossils, which are easily picked out. The mass is thus reduced to from half to two-thirds of its weight, and is then dried. It greatly facilitates further operations, to sort this into separate sizes by passing the dried material successively through the sieves of $\frac{1}{4}$ inch, $\frac{1}{6}$ of an inch, and $\frac{1}{10}$ of an inch mesh. The fine matter passed through the $\frac{1}{10}$ of an inch mesh seldom contains fossils, and may be thrown away.

Now comes the final process of hand-picking from the three sorted lots of debris. These are spread out *thinly* on a slab of slate or a smooth board, and women, at a wage of 1*s.* 6*d.* a day, quickly perform the operation, and readily learn not only to pick out the fossils from the gravelly debris, but also to roughly sort the species.

As an instance of the good results of this process, we would mention that from one cartload of the Buildwas Beds of Wenlock Shale no less than 4300 specimens of one species, *Orthis biloba*, were obtained, besides a much greater bulk of other Brachiopods, amounting together to 10,000 specimens at least; but this does not nearly represent the full wealth of life of this rich horizon, as many of the larger species, and others not completely calcified, would get broken up in the washing process, and we have had to supplement the species obtained by washing with a series of hand-picked specimens.

The whole of the debris has been preserved after picking out the Brachiopods, as it abounds in minute corals and other fossils, which will we hope be investigated by other observers.

The cost of the process, with the aid of a potter's clay blunging machine, amounts to about 18*s.* per ton of materials. This includes the cartage of the shale two or three miles, the whole process of washing, and the hand-picking of the fossils by paid workers.

The following estimate of the thicknesses of the several subdivisions of the Upper Silurian rocks of Shropshire is based on the average of three sections from S.S.E. to N.N.W. across the north-eastern end of the great Shropshire escarpment. One of these passes through the town of Much Wenlock, and the others at distances of about two miles to the east and west.

The horizontal distances of the lines of contour from the base of the Upper Llandovery to the base of the Devonian average from 3½ to 4 miles or about 20,000 feet; and taking the general dip at 12°, the total thickness of the Upper Silurian series can scarcely be less than 4500 feet.

An estimate of the actual thickness of each of its subdivisions is difficult to arrive at accurately, mainly from the fact that most of the zones, both in mineral character and in the range of species, insensibly graduate into each other, and it is probable that no two observers would fix exactly on the same lines of demarcation.

There are perhaps few parts of the country in which the surface features of contours are ruled so closely by their geological structure enabling the eye at a glance to follow all the main subdivisions. Standing on Benthall Edge or Wenlock Edge, the most prominent points in the escarpment, three parallel valleys and two well-marked intermediate ridges can be made out at almost every part of the long line of exposure extending from Ironbridge on the north-east to Ludlow on the south-west, the three valleys corresponding with the soft shales and the two ridges with the limestones.

The broad sweeping valley of Ape Dale below the observer to the north-west represents the Wenlock Shale, backed up on its north-western side by the harder beds of Llandovery Limestone and conglomerate forming the base of the Upper Silurian series.

The Llandovery beds on the lines of section may be roughly estimated at a thickness of 160 to 170 feet, of which the conglomerate, closely resembling the Millstone Grit, forms the greater bulk. The overlying Wenlock series attain a thickness of from 2500 to 2800 feet: their principal mass consists of soft shales capped by the Wenlock Limestone, which has determined the beautiful escarpment of Wenlock Edge, overhanging the gentle sweep of Ape Dale, and on the south side forms a regular dip slope into the Lower Ludlow valleys of Much Wenlock and Hope Dale.

No clear line of boundary exists between the limestone and shale, for the one imperceptibly graduates and dies out into the other.

From careful measurements made on Benthall Edge we have ascertained that the compact limestone is from 80 to 90 feet in thickness, and it thickens somewhat in the direction of Wenlock to the south-west. Below the compact limestone rock it becomes interstratified with thin layers of shale. Still lower down it assumes a concretionary structure, and gradually dies out into soft shale, through increasingly distant nodular courses, at about 400 or 500 feet below the crest of the limestone ridges.

On Benthall Edge the Wenlock Limestone dips from 15° to 20° S.S.W.; to the westward the dip decreases to from 10° to 15°, and at the eastern extremity of the escarpment at Lincoln Hill, near Coalbrook Dale, the inclination increases to from 45° to 50°. The upturning may have been continuously gradual or interrupted. It commenced *before* the Carboniferous period, for the Coal-measures rest upon it unconformably, and it continued subsequently, indicated by the fact that the inclination of the margin of the Carboniferous beds is related to the greater or less inclination of the subjacent Wenlock Limestone.

The following proposed subdivision of the great mass of Wenlock Shale, which at the north-eastern end of the Shropshire escarpment, attains a thickness of from 2000 to 2200 feet, has been suggested by the alternation of zones of highly fossiliferous and comparatively barren strata.

As stated above, there is an insensible gradation between the Wenlock Limestone proper and the Wenlock Shale, the shales under the limestone containing scattered concretionary courses of nodular limestone, and it will be convenient to term this intermediate zone "The Tickwood Beds," which may be roughly estimated to include a thickness of from 300 to 500 feet of strata.

They are exposed in the deep road-cutting near the railway bridge between Tickwood and Farley Dingle. There is also a fine natural exposure 2½ miles to the east, by the side of a small stream flowing down the east end of Benthall Edge, opposite Ironbridge; and most of the adjacent cutting on the Severn Valley Railway passes through the base of these nodular limestones and shales. The Tickwood Beds are highly fossiliferous. They contain all the five species of *Spirifer* found in the Upper Silurians of Shropshire, with a larger proportion of individuals than in any other zone. The Tickwood Beds are also the highest horizon in which the new genus *Glassia* occurs, and *Orthis biloba* here attains its highest limit, with the exception that a few individuals occur rarely in the Wenlock Limestone and Lower Ludlow.

Below the fossiliferous Tickwood Beds, from 1800 to 1900 feet of soft shales occur, which are comparatively barren in organic remains, excepting only that at one-third from their base a remarkably rich zone occurs, the horizon of which seems to correspond closely with that of the Woolhope Limestone of Herefordshire, and possibly of the Barr Limestone of Staffordshire, though in Shropshire the calcareous element is wanting. It is exposed on the east bank of the River Severn, a short distance above Buildwas Bridge, in a section including from 70 to 80 feet of shale beds, which we propose to call "The Buildwas Beds." They are also exposed further to the west by the side of the brook south of Harley. Just above the fossiliferous zone of the Buildwas Beds, the monotonous "Mudstone" character of the Wenlock Shale is broken by the occurrence of a few thin bands of a remarkable cream-coloured clay, resembling steatite in texture. The late Mr. David Forbes made for one of us an analysis of these bands, which were found to consist of

Water	13·88	
Carbonic Acid	4·88	= 11·10 of Carbonate of Lime.
Lime	6·22	
Silica	45·48	
Alumina	23·52	
Protoxide of Iron	1·76	
Protoxide of Manganese	0·07	
Magnesia	1·44	
Potash	2·15	
Soda	0·54	
	99·94	

and remarked on the smallness of the per-centage of magnesia in the mineral, which so closely resembles compounds which, from their unctuous feel and external characters, are usually considered to be highly magnesian.

The pale colour of these bands is evidently due to the occurrence of the iron in a state of protoxide, which may perhaps have resulted from the presence of the deoxidising agency of organic matter.

If we place the Tickwood Beds as forming a connecting link between the Wenlock Limestone and the Wenlock Shale, the remainder of the shale may be subdivided as follows:—

Barren Shales of Coalbrook Dale and Ape Dale, or "*Coalbrook Dale Beds*"	1100 to 1200 feet
Fossiliferous zone of Buildwas, or "*Buildwas Beds*"	80 to 100 ,,
Barren Shales of Buildwas Park, or "*Basement Beds*"	500 to 600 ,,

These soft shales have largely determined the configuration of the contours of the district, and represent the sweeping Ape Dale valley of denudation, which spreads out for twenty miles below the supporting ridge of Wenlock Limestone of Wenlock Edge, and have in Coalbrook Dale yielded to the excavation of that picturesque valley.

Some soft shales, about 100 feet thick, overlying the Wenlock Limestone, and exposed in cuttings by the side of the railway between Buildwas and Wenlock, west of the Bradley Lime Quarries, may also pertain to the Wenlock series: in physical character they more nearly resemble the shales of the Wenlock than the overlying Ludlow Beds.

The Wenlock Shale in Shropshire, which cannot be much less than 1800 to 1900 feet in thickness, has a development much in excess of the Wenlock shale in the Malvern district, where Professor Phillips estimated it to be 640 feet thick; indeed, its thickness in Shropshire is greater than in any other district, unless we except its supposed equivalents, the Denbighshire Flags, which Mr. G. Maw believes will be found to belong to a distinctly lower horizon.

The Ludlow Series.—Any definite estimate of the relative thicknesses of the several members of the Ludlow Beds is difficult to arrive at, as at the eastern extremity of the Shropshire escarpment the Aymestry horizon is ill-defined, here and there represented by isolated thin bands of limestone, and again as thick masses of impure concretionary limestone intermixed with shale. Collectively the Ludlow series attains a thickness of from 1200 to 1400 feet, which the Aymestry band divides nearly equally, the Lower Ludlow being a little thicker than the Upper, and consists of softer shales. The Upper Ludlow Beds, as at Burton, near Wenlock, often assume the character of fissile Tile-stones. The Lower Ludlow Beds are exposed in cuttings of the Wenlock Railway between Wenlock and Presthope, and the very base of these beds are seen in the Wenlock Railway east of Wenlock. The equivalent of the Aymestry Limestone is finally exposed in the road-cutting below the Dunge House, near Broseley, and to the west of the Marsh Farm on the high road between Broseley and Much Wenlock. The Upper Ludlow is to be seen by the road-side at Burton, near Wenlock, and is also exposed in Willey Park, and in the bottom of the valley below the Dean Farm, near Broseley.

The beds connecting the Upper Ludlow with the Old Red Sandstone, which are well exposed on the banks of a little stream known as Linley Brook, two or three miles south of Broseley, have been described by Messrs. Roberts and Randall in the Quarterly Journal of the Geological Society of London, vol. xix. p. 229. The upper part of their section given at p. 232 appears to refer to the base of an outlier of the Coal-measures, and the remainder to the base of the Old Red Sandstone and top of the Upper Ludlow. The red micaceous marls in the road-cutting on the Bridgnorth side of the valley clearly belong to the Old Red Sandstone, and these are, we suppose, represented by the bed "*c*" in Messrs. Roberts and Randall's section. Below this the section is described as follows:—

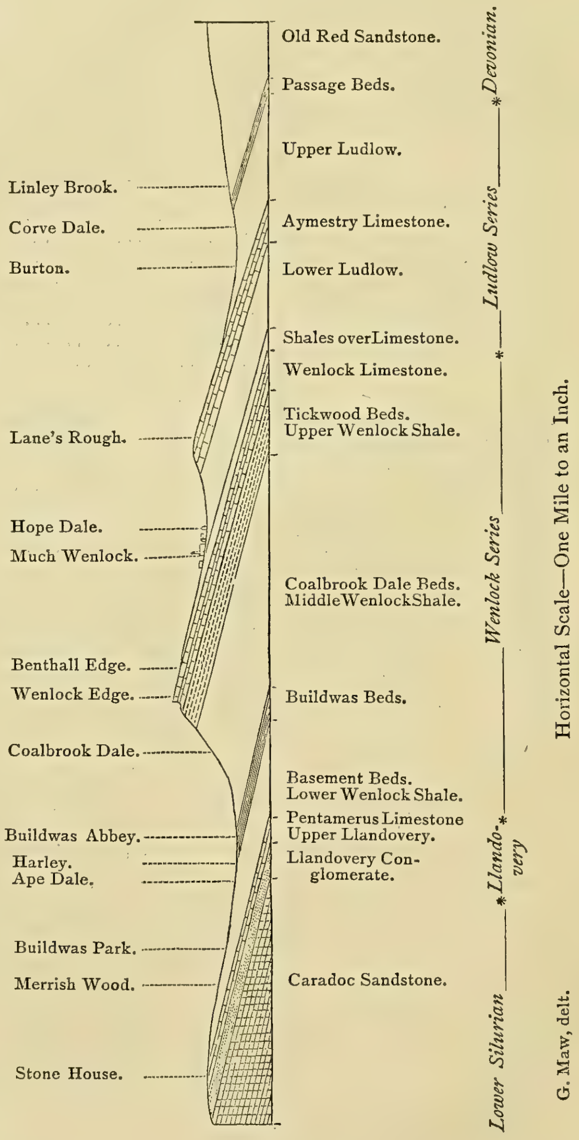
		ft.	ins.
d.	Light-coloured grits, with plant-remains	20	0
e.	Hard micaceous grits, somewhat flaggy, and charged with fish remains ("THE UPPER BONE BED.")	7	0
f.	Flagstones bearing current markings	1	9
g.	Micaceous sandy grits with *Lingulæ*	0	11
h.	Greenish irregularly laminated rock with conglomerate	1	0
i.	Hard calcareous grit with thickly disseminated greenish grains and many broken *Lingulæ*	1	0
k.	Laminated light grey micaceous and sandy shales	20	0
l.	Grey micaceous grits	0	6
m.	Micaceous sandy clays coloured by peroxide of iron	6	0
n.	Yellow sandstones (Downton series), with *Beyrichia*, *Lingulæ*, and including two or more ferruginous bands, containing large quantities of the dermal studs of *Thelodus*, fragments of *Lingulæ*, and minute crystals of quartz. Clusters of *Modiolopsis complanata* occur at the base of this rock (THE LOWER OR LUDLOW BONE BED)	8	0
o.	Hard calcareous shales with fish-remains, *Lingulæ*, etc.	6	0
p.	Flaggy beds of impure limestone, with *Serpulites longissimus*, true Upper Ludlow	4	0
q.	Hard impure limestone, Aymestry series, at base.		

These are without doubt the passage-beds connecting the Devonian and Silurian series; and the only exception we take to Messrs. Roberts and Randall's determination is the supposed occurrence of Aymestry Limestone at the base of their section, as, judging from the thickness of the Upper Ludlow Beds in neighbouring sections, it is improbable that the Aymestry Limestone would come within the section here exposed.

Of Brachiopoda, we believe no species have been found in the Linley Brook section, except *Lingula cornea,* which is abundant.

General Results of the Washings.— The extensive washings and hand-picking from rocks and shales of the Wenlock and Ludlow series in Shropshire has enabled us to ascertain to what horizon each species is peculiar or what was its stratigraphical range. Of course we limit our conjectures to those species of which we have positively ascertained the presence in each horizon. Some few of them may perhaps occur in horizons not indicated in our table, but as they have not come to our knowledge are necessarily omitted.

A glance at our table will show that species were more numerous during the Wenlock than the Ludlow period, that is to say, that while 66 species have been collected from the Wenlock series of Shropshire, only 37 were found in that of the Ludlow period—22 being common to both epochs. These numbers are the result of our personal investigations, but may be slightly modified hereafter or upon still more extended research.



UPPER SILURIAN SERIES OF SHROPSHIRE.

Note.—The Localities are not all on the same line of Section.

The common or abundant species seem generally to have enjoyed the largest vertical stratigraphical range. For example, *Orthis biloba* may be regarded as one of the most abundant species in the Wenlock series, occurring also in diminished numbers in the Lower and Upper Ludlow. The chief horizon, or where it swarms, is the Lower Wenlock Shales or "Buildwas Beds," where we have estimated that upwards of 4500 specimens may be obtained from the washing of a square yard of Buildwas Shale. And from seven tons weight of this shale not less than 25,000 specimens of the shell were obtained, and a vast number more were lost through the washing operations. *Orthis elegantula* is very abundant both in the Wenlock and Ludlow series, and occurs in no less than nine horizons, but most abundant in the Wenlock Limestone and Shales overlying and underlying it. *Orthis hybrida* swarms throughout the Wenlock series. *O. Lewisii* is likewise found to possess an extended range from the Lower Ludlow down to the Lower Wenlock Shales. The other species of the genus are much rarer and have a limited vertical range. Of the interesting small *Streptorhynchus nasuta* a single specimen was found by the Rev. H. G. Day in the Wenlock Limestone of Benthall Edge. Among the Strophomenidæ, *St. rhomboidalis* alone enjoys the greatest vertical range, and is at the same time the most abundant species of the group. *Leptæna transversalis* and especially *L. segmentum* are very abundant species, while *Chonetes lepisma* swarms in the shales above the Wenlock Limestone, but has not hitherto been found in Shropshire at any other horizon with the exception of that of the Lower Ludlow. Next to *Orthis biloba, Atrypa reticularis* is the most abundant species throughout the Wenlock series, and is likewise very common in the Lower Ludlow and Aymestry Limestone. *Atrypa Barrandi* is a very abundant Wenlock species. *Meristella tumida* possesses an extensive vertical range. Five species of *Spirifera* have been collected, but of these the small *Sp. crispa* is the most abundant; it swarms in the Wenlock Limestone, and especially in the shales that underlie it. *Nucleospira pisum* is a very abundant species in four horizons of the Wenlock series. *Retzia Salteri* and especially *Retzia Bouchardi* are very common species in the Wenlock Limestone and its Shales. Among the *Rhynchonellidæ*, *Rh. borealis* is immensely abundant in the Wenlock Limestone and in its underlying shales, while *Rhynchonella Wilsoni* is most abundant in the Ludlow rocks.

It is also worthy of remark that while the species belonging to the Clistenterata are prevalent in the Wenlock series, the reverse takes place for the Tretenterata. For example, five species of *Lingula* occur in the Ludlow series, while two only have occurred to us out of some fifty thousand specimens of Wenlock Brachiopoda, *Lingula Symondi* and *Orbiculoidea Forbesii* being the only abundant species in the Wenlock series, and these apparently almost restricted to the Lower Wenlock Shales. A glance, however, at the table (see over-leaf, pp. 108 and 109), will obviate the necessity of further remarks on this subject. The 81 species recorded in our table belong to some 22 genera.

BRACHIOPODA FROM UPPER SILURIANS OF SHROPSHIRE.

GENERA AND SPECIES OF BRACHIOPODA. r Rare. r r Very rare. c r Not very abundant. c Common. c c Very abundant.	LUDLOW SERIES.				WENLOCK SERIES.						
	Passage Beds. (Linley Brook.)	Upper Ludlow.	Aymestry Limestone.	Lower Ludlow.	Shales over Wenlock Limestone.	Wenlock Limestone.	Upper Wenlock Shales. (Tickwood Beds.)	Mid. Wenlock Shales. (Coalbrook Dale Beds.)	Lower Wenlock Shales. (Buildwas Beds.)	Basement Beds, or Buildwas Park Beds. Lowest Wenlk Shales.	Upper Llandovery.
LINGULA *Symondsii*, Salter......	...	...	r	...	...	...	r	...	c		The list of Llandovery species is not yet complete.
——— *Lewisii*, Sow.	...	...	c c								
——— *striata*, Sow.	...	...	c r	c r							
——— *minima*, Sow.	...	c c									
——— *lata*, Sow.	...	c	c	c c							
——— *cornea*, Sow.	c	...	r								
ORBICULOIDEA *Forbesii*, Dav....	...	...	...	...	...	...	r	...	c		
DISCINA *rugata*, Sow.	...	c	...	c							
——— *Morrisii*, Dav.	...	...	...	r							
——— *striata*, Sow.	...	r									
PHOLIDOPS (*Crania*) *implicata*, Sow.	...	r r	...	r r	r r	...	c r	...	r r		
DINOBOLUS *Davidsoni*, Salter ...	...	...	...	...	...	r r					
WALDHEIMIA *Mawei*, Dav.......	...	...	...	...	r r	...	c r				
? ——— *Glassei*, Dav.......	...	...	...	...	...	...	...	...	r		
MERISTELLA *tumida*, Dalman...	...	...	c r	...	r r	c	c	...	r r		
——— *didyma*, Dal.	...	...	c r	...	...	r	...	...	r r		
——— *læviuscula*, Sow. ..	...	...	...	...	c r	c	r	...	r		
? ——— *Mawei*, Dav.	...	...	...	...	...	r r					
SPIRIFERA *plicatella*, var. *radiata*, Sow.	...	...	c r	...	r	c	c r	c r	c r		
var. ——— *interlineata*, Sow.	...	...	r	...	r	c r	c r				
——— *crispa*, Linné.	...	...	...	c r	r	c c	c c	...	c		
——— *elevata*, Dal.	...	?	...	...	...	c c	c				
——— *sulcata*, His.	...	...	...	...	...	c r	r r				
CYRTIA *exporrecta*, Wahl.	...	...	...	...	...	c	c	c r	c r	r r	
NUCLEOSPIRA *pisum*, Sow.......	...	...	...	...	...	c c	c c	r r	c c		
ATRYPA *reticularis*, Linné.......	...	...	c	c c	c c	c c	c c	c	c c	c	
——— *aspera* (small var.) Schloth.	...	...	...	...	r r	c r	r				
——— *marginalis*, Dal.	...	...	...	...	...	c r	c r	...	r		
——— *imbricata*, Sow..........	...	...	...	...	...	r					
——— *Barrandi*, Dav.	...	...	...	...	r	c	c c	...	c c	c r	
GLASSIA *obovata*, Sow. sp.	...	...	...	...	...	...	r	r r	c r		
——— *elongata*, Dav.	...	...	...	...	...	...	c	r			
RETZIA *Salteri*, Dav.............	...	...	...	...	r r	c	c r	...	c r		
——— *Bouchardi*, Dav.	...	...	...	...	...	c c	c c	...	c r		
1	2	3	4	5	6	7	8	9	10	11	12

1	2		4	5	6	7	8	9	10	11	12
EICHWALDIA *Capewelli*, Dav. ...	...	...	...	...	...	...	r r	...	c r		The list of Llandovery species is not yet complete.
STREPTIS *Grayi*, Dav.	...	...	...	...	...	...		...	c r		
PENTAMERUS *Knightii*, Sow. ...	...	....	c c								
——— *galeatus*, Dal.	...	...	...	c	c	c	c				
——— *linguifera*, Sow.	...	...	...	...	...	c	c	r	...	r	
RHYNCHONELLA *Wilsoni*, Sow.	...	c	c	c	c						
——— *sphæroidalis*, M'Coy.	...	...	...	...	...	c	c	...	r r		
——— *Lewisii*, Dav.	...	...	...	...	...	r	r				
——— *borealis*, Schl.	...	...	...	...	...	c c	c				
——— *bidentata*, Sow..........	...	...	...	r	...	c r	c r	...	r		
——— *Stricklandi*, Sow.	...	...	...	...	...	...	c r				
——— *cuneata*, Dal.	...	...	...	...	...	c	r				
——— *nucula*, Sow.	...	...	...	c	...	r					
——— *Dayi*, Dav.	...	...	...	...	...	c	c r	...	c r		
——— sp.	...	...	...	...	...	...		r			
——— sp.	...	...	...	...	...	...		...	r		
——— *deflexa*, Sow.	...	...	...	...	...	c	c				
——— (? *Atrypa*) *depressa*, Sow. (genus uncertain)	...	...	...	...	...	...	...	...	r r		
——— (? genus uncertain) *navicula*, Sow. ...	...	c	c								
ORTHIS *biloba*, Linné.	...	c r	...	r	c r	r r	c	...	c c		
——— *lunata*, Sow.	...	c	c								
——— *elegantula*, Dal.	...	c r	?	c r	c	c	c	c r	r	r	
——— *elegantulina*, Dav. ...	...	c	...	...	...	...	c	r	c c		
——— *hybrida*, Sow.	...	...	...	c	c c	c c	c c	c c	c c		
——— *Lewisii*, Dav.	...	...	...	r	r	r	r	c	c c		
——— *Bouchardi*, Dav.	...	...	...	...	...	c	c r	...			
——— *rustica*, Sow.............	...	...	...	...	...	c r	c r	...	r		
——— *Walsalliensis*, Dav. ...	...	...	...	...	...	...	...	...	c r		
——— *æquivalvis*, Dav.	...	...	...	...	...	...	...	...	r r	r r	
——— *biforata*, Schl.	...	...	...	...	...	...	...	...	r r		
STREPTORHYNCHUS *nasuta*, Linst.	...	...	...	...	...	r r					
STROPHOMENA *Dayi*, Dav.	...	...	...	...	...	...	...	...	r		
——— *rhomboidalis*, Wilkens	...	...	r	r	...	c	c r	r	c r		
——— *furcillata*, M'Coy......	...	...	...	r	c r	r	r				
——— *euglypha*, Sow.	...	...	...	...	...	r					
——— *antiquata*, Sow.	...	...	...	...	...	r					
——— *imbrex*, Pander..... ...	...	...	...	...	...	...	...	...	r		
——— *pecten*, Linné.	...	...	...	...	...	r	r	...	r		
——— *filosa*, Sow.	...	c	c	...	...	r					
——— *ornatella*, Salter	...	c									
——— *Fletcheri*, Dav.	...	...	...	...	...	r					
LEPTÆNA, *transversalis*, Dal.	...	...	...	...	...	...	c r	r	c	r	
——— *segmentum*, Angelin	...	...	...	c r	...	r	c	c	c c		
——— *lævigata*, Sow.	...	...	...	c							
CHONETES *lepisma*, Sow.........	...	...	...	c	c c						
——— *minima*, Sow.	...	...	...	r r	...	...	...	...	r r		
——— *striatella*, Fischer......	...	c	c	c							

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

III.—ON A CASE IN WHICH VARIOUS MASSIVE CRYSTALLINE ROCKS INCLUDING SODA-GRANITE, QUARTZ-DIORITE, NORITE, HORNBLENDITE, PYROXENITE, AND DIFFERENT CHRYSOLITIC ROCKS, WERE MADE THROUGH METAMORPHIC AGENCIES IN ONE METAMORPHIC PROCESS.

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Part II.

(Continued from page 65.)

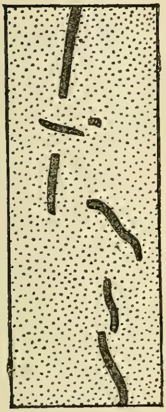
B. THE RELATION OF THE CORTLAND ROCKS TO THE OTHER ROCKS OF WESTCHESTER COUNTY.

THE above brief description of the Cortland rocks prepares the way for a consideration of their relation to the other rocks of the county. The following questions arise: Are they one with the latter in system? are they rocks of an earlier system? or are they eruptive rocks, and not metamorphic, and hence, of no bearing on the general question as to the age of the Westchester limestones and the associated schists?

1. *Evidences of more or less Complete Fusion.*

The evidences of fusion or plasticity are many; and, taking them collectively, they are decisive. They are exhibited in the following ways: (1) The massive character of the crystalline rocks over so large an area, and a general resemblance in them to igneous rocks; (2) the great size of the hornblende crystals in some of the quartz-diorite, and the well-defined crystals of hypersthene in part of the norite, resembling the augite crystals of some volcanic rocks, facts indicating freedom of molecular movement during the process of crystallization; (3) the broken condition of the crystalline individuals in some places, which is evidence of movement while in a pasty state after the beginning of solidification; (4) the occurrence in the massive rocks of included fragments of other rocks, like the inclusions in many trap or basaltic ejections: (5) the existence of dykes or veins of the hornblendic and other rocks, of very various sizes, intersecting the adjoining rocks.

The inclusions are remarkably numerous in some portions of the region, and are often of wonderful magnitude. About Cruger's station, in the soda-granite and quartz-diorite, they occur from an inch in breadth to many feet; one seen in the face of a bluff on the railroad, between three and four hundred yards north-east of Cruger's station, has a maximum breadth of eighteen feet and a length but little less, and consists of garnetiferous mica-schist like that within a fourth of a mile to the east and south; and this is not the largest in that region. They abound also in the chrysolite rocks and norite of Montrose Point and Stony Point, and in the limestone of Verplanck Point. They usually consist of the various materials which constitute the schist of the vicinity, even to the magnetitic garnet rock, quartzite, etc.



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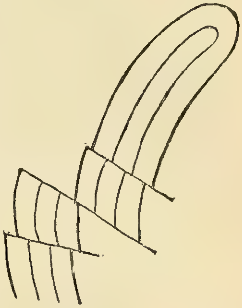
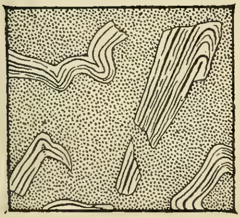


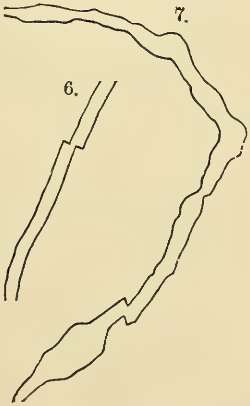
4.

Figure 3 represents ($\frac{1}{30}$ of the natural size) an example from the soda-granite, half a mile west of Cruger's, where displaced fragments of a thin layer of mica-schist occur in the granite. Fig. 4 ($\frac{1}{12}$ the natural size) is of an inclusion in the norite of Montrose Point; the distorted form, the fractures, and the faults appear to be evidence of former free movement in the massive norite. Fig. 5 represents a surface three feet square from a large brecciated pyroxenite adjoining directly the crystalline limestone on the shores of the Hudson at Verplanck Point. The masses in this strange breccia are contorted fragments of the limestone, one or two feet long, the thin layers of which have been brought out prominently by surface erosion.

The examples of what appear to be veins or dykes are also numerous. They cut through the chrysolite rock and norite of Stony Point and Montrose Point, and through the crystalline limestone of Verplanck Point. Those at the last-mentioned place, facing the river (north of the foot of Broadway), vary from an inch in width to over fifty feet. Some are simply faulted bands, like Fig. 6.

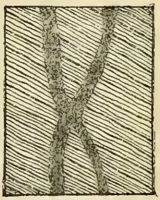


5.



6.

7.



8.

Others have more irregular courses, as in Fig. 7, representing eight feet from a vein at Verplanck Point. Fig. 8 shows a crossing of two small veins from the same limestone region. Some, if not all, of such veins must, therefore, be true veins or dykes; and are evidence as to the former fused or plastic condition of the material and its injection into fissures. Veins formed in this way are not veins of infiltration or segregation, that is, they are not due to the filling of fissures by material supplied slowly in solution or vapour; for no difference in coarseness of texture or structure exists between the rock constituting them and that of the massive rock elsewhere; they are just such as have been made by simple injection.

There are also peculiarities in the exterior of inclusions, and in the walls of veins or dykes, in some cases, which favour the idea of fusion. At Verplanck, the limestone of the wall is often discoloured for two or three inches, and sometimes penetrated by the material of the vein, or contains minute crystals of hornblende; and in other cases, the limestone is impregnated with the hornblendic or augitic material in irregular lines or bands, so that surface erosion has left a complexity of small curving ridges. The crystallization of the limestone adjoining the vein is sometimes coarser than elsewhere; though, in general, no difference is apparent. On a small point, just north of the region of veins, part of the limestone is of the coarsest kind, the crystalline grains over a fourth of an inch broad, while the larger part is very fine in grain, like the most of the Verplanck limestone —a fact that indicates the local action of escaping heat.

Still more positive evidence, if possible, of fusion is shown at the junction of the schists of Cruger's Point with the soda-granite, where the schist itself bears evidence of partial fusion and exhibits other contact-phenomena.

The proof of the crystallization of the rocks from a more or less perfect state of fusion or plasticity is thus complete.

2. *Evidences as to Condition of Fusion.*

But, admitting fusion or a plastic condition, the question still remains:

Were these once-fused rocks fused approximately *in situ*, that is, where, or near where, they now lie; or were they erupted through fissures from great depths below? that is, using Dr. Hunt's terms, are they indigenous, or are they exotic?

a. *The results are partly the same whichever the condition of fusion.* —If they were fused where approximately they now lie, that fusion must have come from accessions of heat, and such accessions may have resulted from the movement and friction connected with an upturning of the rocks; and it may hence have been one of the results, in that region, of metamorphic action at an epoch of general metamorphism; and if so, at the very time that these rocks became fused or plastic through the process, other rocks of the region, owing to less extreme metamorphic action, or to less fusibility, may have been left with their bedding unobliterated; just as much granite in New England and other countries received its crystalline condition in the same process and at the same time with the associated schistose rocks, the gneisses, mica-schists, etc.

All the facts as to fusion which have been presented are consistent with either mode of origin, even to the inclusions and the dykes or veins.

(1) The veins or dykes have the same essential characters whether

made one way or the other. As has often happened in the case of granitic rocks, and even granular limestone, the fused or plastic material, under the pressure attending the subterranean movements, would have entered and filled all fissures that might have been opened to it, and so have made veins or dykes having the sizes of the fissures, whether large or small, and possessing also a uniformity of grain like that of ordinary erupted rocks.[1]

(2) Again, whatever the process of ejection, fragments, large or small, of any rocks adjoining such fissures might have become included in the fused or plastic material.

(3) Moreover, the contact-phenomena in the case of veins so formed may be as decided and extensive as in that of any dykes or erupted masses.

(4) Further, the evidences of fluidal movement exhibited in the broken condition of many of the crystalline grains would be the same. Such a fragmenting of grains taking place after the stiffening of incipient solidification requires but a moderate amount of movement, and this is all that such circumstances would admit of. One foot would suffice; thousands would be impossible.

(5) Again, the resulting rocks need not, and generally do not, differ in kinds from erupted rocks of deeper source. In such fusions in the course of a process of metamorphism, the thickness of the rocks undergoing common movement may have a depth of 20,000 feet or more, and the fusion, therefore, would not be superficial. The view that many of the ordinary erupted rocks are nothing but fused sedimentary rocks need not be here discussed. The improbability of the view comes from the improbability of any movements in the earth's crust being sufficient to fuse its own rocks or the overlying sediments. But the epochs of metamorphism are the times not only of the profoundest movements of the crust, but also of the most thorough upturning of sedimentary beds, and if these are ever melted through the friction of upturning, or by its aid, then would be the occasion for it.

(6) Veins made at such an epoch by the injection into fissures of any rock so fused might have any extent, even that of the whole depth of the rocks metamorphosed; for the fissures may be thus deep. And the material filling them, since it might be that of the bottom rocks, might be wholly unlike that of the rock on either side of all the higher parts of the fissure.

But while there may be these resemblances between the effects of metamorphism and those of deep-seated eruption,

b. *The results of fusion of sedimentary beds under metamorphic action may have distinguishing peculiarities.—First:* The kinds of rocks so resulting are likely to vary greatly at comparatively short intervals, because sedimentary beds often vary thus. They should not have that uniformity for scores or hundreds of square miles

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[1] In the writer's Manual of Geology (1880), veins of this kind are called veins of plastic injection, an abbreviation of the full statement that they were made by the injection of material rendered plastic or fused during a process of metamorphism. They are better called dyke-like veins.

which often characterizes ejections that have come up from regions beneath the supercrust.[1] Sediments, and therefore sedimentary deposits, are liable to frequent and sudden changes as to material, which igneous outflows cannot imitate. *Secondly*, the rocks are likely to have no columnar (basaltic) structure; because the fractures to be filled in such cases are fractures in rocks which are participating in the movement, and which, therefore, are heated rocks, and not cold.

Again, the phenomena of contact and the facts as to inclusions, structure and superpositions, may have distinctive peculiarities.

c. *The condition of fusion or plasticity in the Cortland region.*—To answer the question before us we have, therefore, to consider more closely than has been done the phenomena of contact of the schistose with the massive rocks over the Cortland region, the peculiarities of some of the inclusions, the characteristics of some of the so-called veins or dykes, and the characters of the rocks as to their transitions, structure, and relative positions.

3. *Special Facts from the Cortland Region.*

a. *Contact-phenomena between the schistose and massive rocks; facts connected with the inclusions; stratigraphical relations to the limestones.*—The facts with reference to inclusions and all contact-phenomena bear directly, as will appear, upon the question as to any stratigraphical relation in the Cortland rocks to the limestones; and they are, therefore, here taken from the vicinity of particular limestone areas.

(1) *The vicinity of Cruger's limestone area.*—The small limestone area near Cruger's (see map) lies mostly to the south and east of the station; only a small portion about forty feet in greatest width borders the river west of it, beyond the first brickyard (*l*), the rest of the westward extension of the limestone being beneath the river. The schistose rocks directly and conformably adjoin it on the north, the average strike of both being N. 70° E. and the dip 75° to the northward. In the south-eastern portion of the area there is a twist in the whole to the north-west. The limestone is finely crystalline granular, mostly white in colour, and over the hills to the eastward contains crystals of white pyroxene.

The schist north of the limestone has a thickness of about a thousand feet. Toward the limestone, it is a silvery mica-schist containing a little black mica and an abundance of very small garnets. A hundred yards or so to the north it is staurolitic, the staurolite occurring in grains of a clear chestnut-brown colour and rarely in distinct crystals; and it also in some parts becomes quartzose and consequently thick-bedded. There are, besides, seams containing much magnetite; and at one place an intercalation of a black micaceous rock containing some felspar which is about equally orthoclase and a soda-lime species. After another hundred to a hundred and fifty yards northward, in the course of which it becomes increasingly staurolitic and garnetiferous, and passes in

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[1] The term *supercrust* is used for that part of the earth's crust which has been made by sedimentation, the *true crust* being restricted to the part beneath which is a result simply of cooling.

places into a true gneiss, it comes to its end against soda-granite and quartz-diorite. Thus within a breadth of only 250 to 350 yards, there is here a passage from a stratum of crystalline limestone through conformable schists, to the massive rocks along which we have to look for contact-phenomena.

The facts here described are mostly from three south-to-north sections: *Section* 1, 300 to 400 yards west of the Station (*l* to *n*, on the map); *section* 2, about 700 yards (*p*); *section* 3, about 900 yards (*q* to *s*).

In section 1, *l* to *m* is the schist; at *m* is soda-granite, which becomes hornblendic twenty-five feet above, toward the road; and then at *n*, on the north side of the road, the rock is of coarse quartz-diorite. (The locality *n* is that of the first outcrop of rocks on the road going north-west from the railroad station.) The contact-phenomena in this section are as follows.

In the first place, the mica-schist is even in bedding against the limestone; becomes more and more contorted to the northward, or away from it; and is full of flexures of a yard or so in span for the last fifty feet or more south of the junction with the granite.

With the increase in the flexures of the layers, the schist becomes interlaminated with nodose-lines of quartz, vein-like in origin; and, besides, the garnets become somewhat larger. At the junction referred to, the schist is mostly a garnet rock containing much fibrolite and staurolite, and the latter is in some places granular-massive in a small way. Just below the granite, the layers are a compact body of flexures, and *in the soda-granite* there is another flexed layer rather faintly indicated.

Figure 9 represents the condition here described; it was taken from the west side of a little bluff at *m*; the height is twenty feet. The dotted portion is that of the soda-granite. The garnet rock of the flexures under the granite contains, like the granite, soda-lime (or triclinic) felspars, with little orthoclase; and the first foot of the granite is strongly garnetiferous;—facts which show a degree of transition in the material of the two rocks. The flexed bed within the soda-granite is gneissoid in character and of darker

FIG. 9.

FIG. 10.

grey colour than the granite; it is quartzose and garnetiferous, strongly micaceous with black mica, and contains magnetite and a little staurolite. The schist is consequently not a schistose portion of the granite, but a distinct bed; it is like the schist in its minerals, but in its more gneissic character indicates that it is intermediate between the schist and the soda-granite. The eastern face of the same ledge is about a dozen feet to the east of the western, and here the junction of the schist with the granite looks more abrupt, but partly in consequence of erosion; above this plane of junction, in the mass of the granite, distinct though fainter indications of flexed beds exist. The change above *m* from soda-granite to quartz-diorite is simply a change in the substitution of hornblende for the larger part of the black mica, the felspars being equally triclinic in the two, and the quartz equally deficient in amount. At a small bluff, 160 yards to the west of *m* (at *o*, see map), the change is more abrupt than between *m* and *n*; in only six feet, the rock passes from soda-granite to diorite.

A natural inference from the series of facts presented in this section, those as to the flexures in the schist as well as the changes at the junction of the schist and granite, would be that the heat of metamorphism increased from the limestone northward toward the granite and diorite region, the heat being a consequence in part, if not chiefly, of the movement and friction attending the flexing, and that consequently there was produced a more and more yielding condition in the material of the schist as the region of complete fusion was approached, and, at the junction, perhaps a fusing and obliteration of portions of some layers of the schist; and that a bed of schist existed in the granite which approached somewhat the granite in character, but which, owing to the nature of its material, was not wholly obliterated.

But, are not these flexed portions of beds fragments that were broken off and carried up by the fused or plastic material as it rose from depths below? They lie so conformably to the flexures of the schist as to suggest a negative reply to this query.

Sections 2 and 3 (at *p*, and *q r s*, on the map) show inclusions on a grander scale.

Section 2 extends up the face of the first high bluff of bare rock west of *m* (a bluff that has by its east foot a path leading up among the trees to a fine spring).

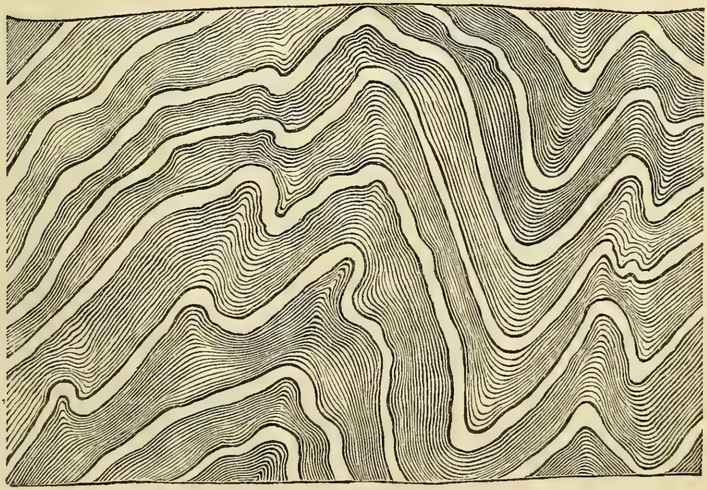
Figure 10 represents a portion of the surface of the bluff about forty feet wide. Below is the hard contorted schist, a well-bedded micaceous schist, becoming in its upper part true gneiss; and above this, as the dotted surface shows, there is soda-granite, and then, after a few yards of this rock, the diorite or hornblende rock, which is indicated in the diagram by short lines instead of dots. About a yard above the schist, *within the mass of the granite*, a schistose layer, about a foot thick, occurs; and eight to nine feet above this another *in the diorite*, and *both are conformable to the schist.*

The upper bed of schist shows (in thin slices) that it is a quartzose, dark-grey gneiss, containing much black mica and garnet, but also much triclinic felspar and apatite, and in these two points approaching the soda-granite,—thus evincing a very marked transition in its composition toward that of the soda-granite. The first bed above it, lying in the granite, is similar to the schist in its black mica and quartz, but contains very little garnet; but like the soda-granite, it contains much apatite and more triclinic felspar than orthoclase. Still other parallel beds are indicated at higher levels; one of them exists at the top of the bluff, twenty-five to thirty yards above the upper bed in the figure.

The facts look toward the same conclusions as those from section 1.

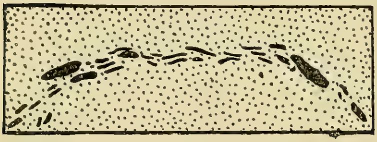
Section 3 was taken along a line about half a mile west of Cruger's Station, commencing on the river at *q* (see map, p. 60), in front of the most western of the brickyard sheds, and passing *r*, a point north of the upper shed, to *s*. For a distance of about 500 feet from the shore, the rock is mica-schist; next follows soda-granite for about fifty feet; then, very coarse diorite (the hornblende crystals in some parts finger-like in size) for 90 to 100 feet; then soda-granite again. At the shore the schist is nearly evenly fissile; 450 feet north, on the line of the section, it is like the six feet square represented in Fig. 11. In the next fifty feet, the flexures are distinct, but half faded out or nearly obliterated; and this is the last step before the soda-granite, the once plastic or fused rock, begins.

Fig. 11.



After twenty-five feet of soda-granite the first (*a*) of the ranges of "inclusions" appears; it is on the side of the road which here leads up the slope. Between three and four yards of the band are represented in Figure 12. As shown, it is in pieces; yet the pieces are not much displaced, which they would be in an erupted rock. The material is greyish-black, and consists of a very chloritic magnetite, with a little black mica, in a feeble amount of base of triclinic felspar. After an interruption it appears again for a short distance to the westward, where it is much more micaceous and garnetiferous; but the exposure is not as satisfactory as in the case of the other bands. Three feet behind this band, that is, to the north, there is a similar one having a parallel position.

Fig. 12.



Eight or nine yards north commences the coarse diorite. At the top of the slope, near the passage of the coarse diorite to the soda-granite, partly in the diorite but mostly in the granite, there are three bands (*b*) within three to five feet of one another, gneissic in constitution. Figure 13 represents about a dozen yards of these bands, in the diorite and granite.

Fig. 13.

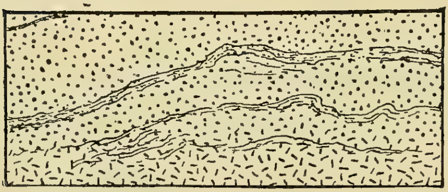


Fig. 14.

The upper or northern of the three bands (b^3) is exposed with small interruptions for *a length of more than one hundred and fifty feet;* and the more eastern portion is shown in Figure 14. The strike is the same as that of the schist.

The rock of the middle of these bands (b^2) is a quartzose gneiss, with black mica, many visible grains and octahedrons of magnetite, and some garnet—resembling the gneiss of some of the nearest schist and unlike the inclosing soda-granite in its excess of quartz, magnetite, and its garnets; and that of the others is similar. About three yards north, but a little to the west, is another band (b^4), one to two inches thick, which has a grey colour, and consists of small spangles of silvery mica, some scales of black mica and chlorite, and grains of magnetite—a thin layer of the mica-schist more magnetitic than usual.

About eight yards north of the third of the bands represented in Figure 12, there is another schistose band (*c*), which is short in the line of the section, but appears again to the eastward and also to the westward; the rock is quartzose, garnetiferous, and includes chloritic magnetite with fibrolite, and other materials of the schist.

Eight to nine yards farther north, in the soda-granite, another band (*d*) exists, with the same strike—that of the schist—which outcrops for *two hundred feet*, or as far as the rocks in the direction are uncovered. This band is grey, like the last, and sparkles with the same pearly mica, but it is made up largely of brown staurolite in a half-granular form, showing but rarely crystalline faces, and contains also disseminated magnetite and some fibrolite and chlorite; a garnetiferous portion contains much black mica. Eight feet farther north, but to the eastward a few yards, a very siliceous schist appears for a short distance. Fifty feet north, in the soda-granite, is still another band (*e*), which contains much chloritic magnetite; and a hundred feet beyond, another thin, grey, micaceous band resembling closely b^4; the condition of a portion of it is shown in Figure 3, on page 111. Farther north, at intervals, other schistose bands exist, and along the north side of Cruger's Point, facing the brick-yards at the foot of Park-street, they are more largely displayed.

(To be concluded in our next Number.)

IV.—CONTRIBUTIONS TO THE PALÆONTOLOGY OF THE YORKSHIRE OOLITES.[1]

PART VII.

By WILFRID H. HUDLESTON, M.A., F.G.S.,
President of the Geologists' Association.

(PLATE IV.)

Genus TROCHOTOMA, Deslongchamps,[2] 1842 = Ditremaria, D'Orbigny, in part.

In England the Great Oolite of Minchinhampton contains the greater number of species belonging to this peculiar group of *Haliotidæ.* Morris and Lycett (Great Oolite Mollusca, p. 80) give a full and interesting diagnosis of the genus, which has only one representative in the Corallian beds of Yorkshire. D'Orbigny figures half a dozen species of *Trochotoma* from the Corallian of France, and Buvignier gives three from the Coral Rag of the Meuse. None are quoted by De Loriol from the Séquanien of Boulogne.

49.—TROCHOTOMA TORNATILIS, Phillips, 1829. Plate IV. Figs. 1*a*, *b*.

Trochus tornatilis, Phillips, 1829, Geology of Yorkshire, vol. i. pl. iv. fig. 16.
Trochus discoideus, Rœmer, 1836, Ool. Geb., p. 150, pl. xi. fig. 12.
Trochotoma discoidea, Rœmer, 1850, Morris and Lycett, Gt. Ool. Moll. p. 84. pl. x. fig. 10.
Trochotoma discoidea, Buv., 1852, Stat. géol. de la Meuse, p. 39, pl. 25, figs. 10-11.
Ditremaria amata, D'Orb., 1852, Terr. Jurass. vol. ii. p. 389, pl. 343, figs. 3-8.

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[1] Concluded from the February Number, p. 59.

[2] I am indebted to Professor Morris for the following note with reference to the authorship of this genus:—"Described by Deslongchamps in 1841, and first published in the Mem. Soc. Linn. Norm. vol. vii. 1842. Lycett sent the proposed name with a specimen to Sedgwick in 1841, but without any description. The first description by Lycett appears to be in the Annals and Magazine of Natural History for 1848, 2nd series, vol. ii. p. 253, and more fully in the Great Oolite Mollusca, 1850. It would seem therefore that Deslongchamps has the priority of publication. S. P. Woodward in his Manual assigns it to Lycett, although both authors suggested the name *Trochotoma* about the same time, 1841-42."

Trochotoma amata (D'Orb.), 18—, Deslongchamps, Notes palæont., No. vi. p. 46, pl. 3, figs. 3-6.
Trochotoma tornata, Phillips, 1875, G. Y., 3rd edition, p. 359.
non *Pleurotomaria tornata* (Phillips), D'Orb., *op. cit.* p. 564, pl. 422, figs. 6-8.

Bibliography, etc.—It is certainly stretching the rule of priority to the utmost when we adopt Phillips's name for this very widespread and somewhat persistent species. As there is no other species of *Trochotoma* in our Yorkshire beds of this age, it is pretty clear that Phillips's most inadequate figure was intended for the fossil now under consideration. If, however, this figure, unaccompanied as it is by any description, be rejected as insufficient to establish Phillips's claim, we must fall back upon Rœmer's name of *Trochotoma discoidea,* which is in every way preferable.

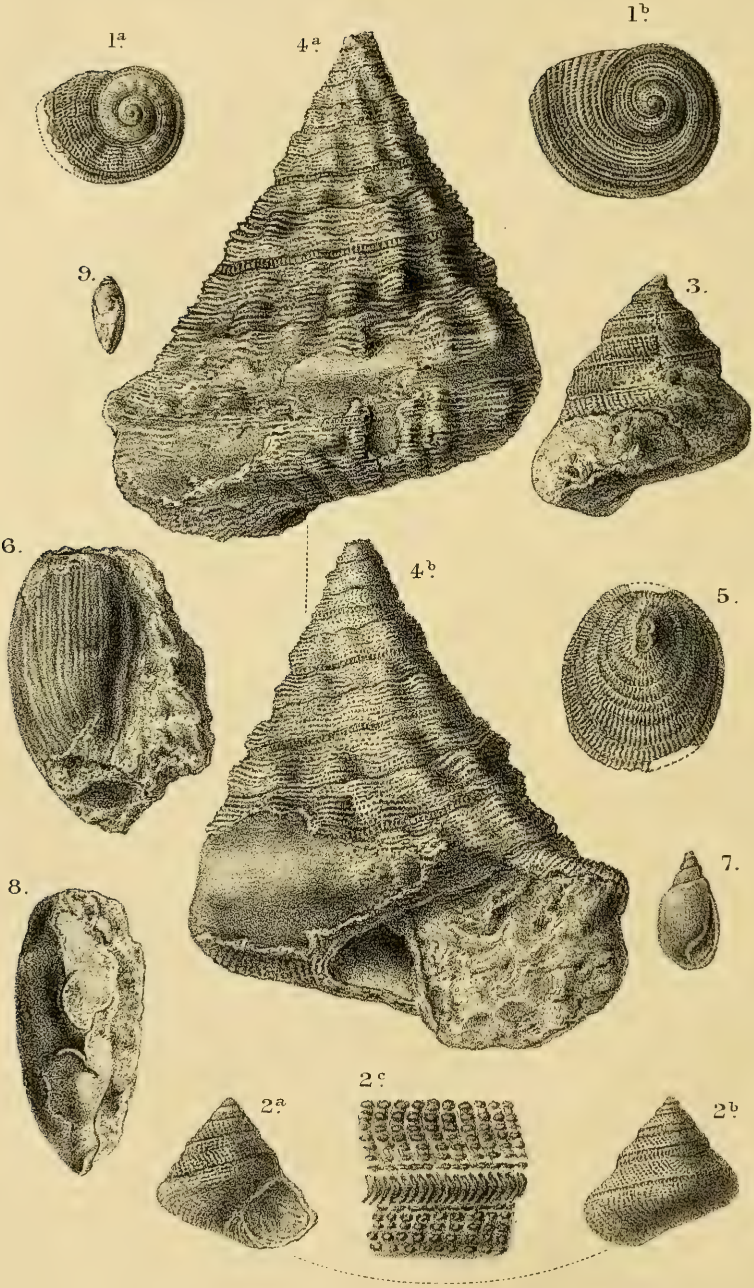
D'Orbigny (Prod. de Pal. Strat. vol. i. p. 354) quotes *Trochus discoideus*, Rœmer, as an Oxfordian fossil, and subsequently (*op. cit.* vol. ii. p. 9) quotes *Ditremaria amata*, D'Orbigny, from the Corallian. In the Terrains Jurassiques he makes no mention of Rœmer's species, but regards the *Trochotoma discoidea*, Buvignier, as a synonym of his own *D. amata.* Brauns (Obere Jura, p. 231) regards Buvignier's species as identical with Rœmer's. Buvignier's figure and description answer excellently to our Yorkshire specimens, which we must therefore identify with the original *Trochus discoideus* of the Coral Rag of Hildesheim.

Description.—Fig. 1*b*. Specimen from the Coral Rag of North Grimston (Strickland Collection).

Height	12 millimètres.
Basal diameter	26 ,,
Spiral angle, about	130°.

Shell very depressed, more than twice as wide as high, largely excavated. Spire composed of about four whorls, which are wide apart, subdepressed in the early stages, and very much so in the body-whorl, which is large in proportion to the rest of the spire. The ornaments consist of regular raised lines parallel to the suture (*i.e.* transverse), and these lines are cut across from left to right by a system of fine striations, producing a delicate pattern. The whorls are bicarinated (a feature not observable in the earlier stage): the posterior keel, which forms the salient angle, contains the fissure. This is elongate, and terminates three millimètres from the present margin of the outer lip, which has been slightly reduced by fracture. The space between the keels is rather excavated, and the anterior keel is rounded off. The same ornamentation is continued in the base of the shell, but the state of preservation does not admit of an accurate description of the aperture.

Fig. 1*a*.—Smaller specimen from the Coral Rag of Brompton (Strickland Collection). This shell has the general character and ornamentation of the one previously described, but is less depressed. Moreover, the body-whorl developes wide undulations across its surface, which yield an additional ornament. The imbricated band of the sinus is very well seen in this specimen, situated, as in the other case, on the posterior keel. The termination, where the loop



A. S. Foord del et lith.　　　　Mintern Bro's. imp.

Corallian Gasteropoda. Yorkshire.

should be, is unfortunately not visible, and the base of the shell is wholly obscured in matrix.

Relations and Distribution.—Some might be disposed to regard the differences between 1*a* and 1*b* as important enough to constitute two species. 1*b* is an exceptionally depressed form, selected for figuring as the best-preserved specimen which I could obtain. It is entirely devoid of the undulations so conspicuous in 1*a*. But we find shells with the outline and dimensions of 1*a* quite as devoid of the undulations as in 1*b*; therefore this can hardly be regarded as a character of importance, though D'Orbigny mentions it in his diagnosis of *Ditremaria amata.* Again there is great variety in the fineness of the ornamentation, but we cannot trace a connexion between any particular degree of fineness and the development of these undulations. If any constant difference can be pointed out, it is that the Grimston and Langton Wold shells are larger and perhaps more depressed than those from the Rag of the Scarborough district, which more resemble the small variety of this species recognized by Morris and Lycett as rare in the Great Oolite of Minchinhampton.

Rœmer's shell, judging from his description, is a smaller and less developed variety, with from two to three whorls. Brauns finds it in the *perarmatus* beds of Heersum and Coralline Oolite of Hanover. The species is not quoted from the Séquanien of Boulogne, nor do I know it from the Coral Rag of the rest of England, though it is decidedly common in the Coral Rag of Yorkshire.

Genus Pleurotomaria, Defrance, 1825.

This genus is not particularly well represented in any member of the Yorkshire Oolites, nor does the Inferior Oolite yield a better list in this respect than subsequent formations. Here therefore we note a great difference between the Inferior Oolite of Yorkshire and of the Anglo-Norman basin, which latter may be regarded as the head-quarters of *Pleurotomaria*, both in numbers and species. On the other hand, the Corallian Rocks of Yorkshire have furnished as many species as the beds of corresponding age throughout the rest of England, though none of the species described can be regarded as common.

50.—Pleurotomaria, sp. Plate IV. Figs. 2*a*, *b*, *c*.

Description.—Specimen from the Passage-beds of the Lower Limestones, Wydale (my Collection).

Length	21·5 millimètres.
Width	22 ,,
Spiral angle	74°.

Shell conical, subturrited, but slightly oblique, scarcely umbilicated. Spire composed of six or seven whorls, which increase regularly and are but slightly angular. Each whorl has only one well-defined keel, which forms the principal prominence, and carries the imbricated *sulcus*. In the penultimate whorl of this specimen an anterior keel is imperfectly developed. The ornaments display considerable irregularity. Above the *sulcus* of the body-whorl the sculpture is granular, that is to say, it consists of a system of transverse ribbing, deeply decussated by longitudinal furrows. Below the last *sulcus* the granular character is less decided, and the base of the shell has numerous fine spiral lines, which decussate with wavy lines of growth. Base rounded and tumid: aperture subquadrate: umbilicus, little more than a notch: columella short and sloping.

Relations and Distribution.—This small variety of *Pleurotomaria* has features in common with many named forms; and yet, when closely compared with these, it is not found to fit any of them exactly. In Yorkshire it has only been noted in one locality, whence but few specimens have been obtained. This shell-bed lies towards the base of the Lower Limestones, and on the same local horizon with the *Gervillia*-beds of Scarborough Castle Hill.[1] It is Oxfordian, and contains several of the fossils of the "Oolithe ferrugineuse" of Viel St.-Remy, etc.

A very near relation is the Cornbrash species described by Lycett (Supplement to Great Oolite Mollusca, p. 24, pl. 31, figs. 8, 8*a*) as *Pl. granulata*, Sow.[2] When we turn to foreign authors, it is clear that the Wydale *Pleurotomaria* has affinities with the *Pl. Münsteri* group, and especially with the variety *Pl. Buchana*, d'Orb. (Terr. Jurass. vol. ii. p. 552, and pl. 417, figs. 6–10). Nevertheless, in this case, although the outline and proportions are very nearly the same, D'Orbigny's fossil from the "Oolithe ferrugineuse" is represented as being more finely marked. Judging, however, from D'Orbigny's figure 8, the base of the two shells is identical. On the whole, the Wydale shell may be deemed a dwarf variety of the *Pl. Münsteri* group, somewhat differing from any form as yet described. There is a form of about the same size, and with many points in common, which occurs in the shell-bed at Cumnor, near the top of the Lower Calcareous Grit. Thus similarity of physical conditions

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[1] It should be borne in mind that the Coralline Oolite of Scarborough Castle is lower geologically than the Coralline Oolite of Malton.

[2] Sowerby's species is a fossil of the Inferior Oolite, originally described (M. C. t. 220, fig. 2) from Dundry. He gives two figures, but does not distinguish them by letter or numeral. The specimens are not in the type collection at the New Natural History Museum. Nevertheless, since a fossil similar to the right-hand figure is so common in the Inferior Oolite of Bradford Abbas and elsewhere, we cannot be in doubt as to the form of Sowerby's species. That author says that "the granulated surface is the result of decussating furrows which vary in depth and number in different individuals." I have examined a large series of English specimens from the Inferior Oolite, and find that Sowerby's *P. granulata*, though subject to great variety, has a much wider spiral angle, is more umbilicated, and has a greater variety of ornamentation. Nevertheless there are forms in the Inferior Oolite of Normandy classed by Deslongchamps as varieties of *P. granulata* (see Mem. Soc. Linn. Norm. vol. viii. pl. 16, fig. 6*a*), which lead up to the Cornbrash species, and also to the form now under consideration. See also a figure in Quenstedt's Der Jura, pl. 57, fig. 7, of a fossil from the Brauner Jura delta, p. 414. Still the elements of the *Pleurotomaria* in the Yorkshire Cornbrash, which must be regarded as very closely related to the shell now figured, are clearly not those of *Pl. granulata*, Sow., in any respect beyond the granulated character of the general sculpture. We have seen that Sowerby regarded the granulated surface of his species as the result of decussating furrows *varying in depth and number*; hence, when we bear in mind likewise the great differences in external appearance due to various conditions of mineralization, too much stress should not be laid upon mere granulation.

is accompanied by approximately identical modifications of form and growth.

51.—Pleurotomaria Münsteri, Rœmer, 1839. Not figured.

Pleurotomaria Münsteri, Rœmer, 1839, Suppl. to Ool. Geb. p. 44, pl. xx. fig. 12.
Idem, D'Orbigny, 1852, Terr. Jurass. vol. ii. p. 549, pl. 416, figs. 4-8.

There occurs in the Upper Limestones at Filey Brigg, and elsewhere about the same horizon, a *Pleurotomaria* which, though not much larger than the one previously described, approaches still more closely to Rœmer's species in its outline, dimensions, and the step-like character of the whorls, which has only one keel. In more typical specimens of *Pl. Münsteri*, such as those from the Elsworth Rock, and especially from the *Trigonia*-beds of Osmington (Corallian Series of Weymouth), the transverse ribbing is more continuous and less granulated than in the Yorkshire specimens. This arises from the comparative shallowness of the decussating furrow, and is probably too much the result of varying conditions of preservation to be regarded as a feature of primary importance.

Though tolerably common, I have never been able to obtain a specimen in good preservation, but there is a fossil in the Leckenby Collection marked "*Pleurotomaria granulata*, Sow., Lower Calcareous Grit, Filey Brigg," which I have very little doubt belongs to this variety, and probably comes from the Upper Limestones of that locality.

52.—Pleurotomaria reticulata, Sowerby, 1821. Plate IV. Fig. 3.

Trochus reticulatus, Sowerby, 1821, Min. Conch. table 272, fig. 2.

Bibliography, etc.—Sowerby's original specimens were from the Lower Kimmeridge of Ringstead Bay, observed also at Portland Ferry in the same formation. He gives as the diagnosis "conical, transversely reticulate-striated; whorls bicarinated, base convex."[1]

Description.—Specimen from the Coral Rag of Settrington (my Collection).

Length	33 millimètres.
Width	31 ,,
Spiral angle	? 73°.

Shell trochiform, turrited, but slightly oblique, scarcely umbilicated. Spire composed of six or seven whorls, which are strongly bicarinated, the upper keel being more acute than the other. It is situated at the angle of the whorl, and carries the band of the *sinus*. The imbrications are smoothed by attrition. The ornaments consist of a system of transverse lines, met at right angles by a system of longitudinal ones, thus producing a net-like or reticulate structure, which appears, however, to be subject to considerable irregularity, and sometimes approaches the granular ornamentation of the

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[1] Both the figure and description by Sowerby indicate that this species should be bicarinated. Yet in the type collection at the New Natural History Museum are three specimens not figured (the figured specimen should be at Cambridge), which clearly come from the *Trigonia*-beds of Weymouth, and belong to its very close relative, *Pl. Münsteri*, the more usual Oxfordian form.

Wydale species. The specimen towards the last whorl is indifferently preserved.

Relations and Distribution. — The differences between this form and the more typical *Pl. Münsteri* are, that this one has a narrower spiral angle, and has the whorl distinctly bicarinated, and each whorl is less completely overlapped by the succeeding one, so that the sutural excavation is more marked. On the other hand, it resembles the types of that species in having the ornamentation reticulated rather than granulated, that is to say, the transverse ribbing is not cut through sufficiently deeply to produce a very distinct granulation, though there is an approach to it in some places.

With respect to distribution this must be viewed as representing *Pl. Münsteri* in the higher beds. It is clearly a Kimmeridge form, though I cannot find it noticed on the Continent from beds of that age. Rare in the Coral Rag of the Howardian Hills.

53.—Pleurotomaria Agassizii, Münster, 1844. Plate IV. Figs. 4*a*, *b*.

Pleurotomaria Agassizii, Münster, Goldfuss, 1844, pt. 3, p. 71, pl. 186, fig. 9.
Idem Idem, D'Orbigny, 1852, Terr. Jurass. vol. ii. p. 572, pl. 426, figs. 1–5.

Bibliography, etc.—Münster's species was from the Corallenkalke of Nattheim. His description is not very close, but the figure (enlarged) is fairly like the specimen now under consideration. That this is the species intended by D'Orbigny there is every reason to believe, as his description in most respects tallies with the North Grimston specimen, though his figure, which is almost too good for a fossil, is somewhat different.

Description.—Specimen from the Coral Rag of North Grimston (Strickland Collection).

Length	72 millimètres.
Width	60 ,,
Spiral angle	60°.

Shell conical, trochiform, umbilicated. Spire composed of about nine whorls (seven now remain without the apex). These, with the exception of the last whorl, increase under a regular angle, and are so close, towards the apex, that the suture can with difficulty be made out. They are nearly flat, and down to the margin of the penultimate form an almost unbroken cone. The penultimate is rather swollen, and the last whorl is obtusely angular. The ornaments vary in different parts of the shell. In the posterior whorls the closely-set transverse ribbing is fine and rather granular. Anteriorly the system of transverse costæ is wider apart, sometimes granulated, sometimes almost continuous, but on the whole irregular and coarsish over the entire surface of the two last whorls. A characteristic feature is a double row of thick rough tuberculations, which become very prominent in the anterior whorls. Between these the imbricated band of the sinus is conspicuous, occupying a postion a little above the middle of each whorl. The base is nearly flat, and has the irregular ornamentation of the rest of the body-whorl without the tuberculations. The sides of the umbilicus are steep, and the columella but slightly inclined outwards.

The aperture is irregularly quadrate: angular externally, and but little cut away on the interior.

Relations and Distribution.—This is by far the finest specimen of the ornamented group of *Pleurotomaria,* allied to *Pl. anglica,* which has ever been found in beds of this age in Yorkshire. There is a specimen in the Leckenby Collection—length 32mm., width 28mm. —which may be regarded as representing the usual size of this somewhat rare form. Thus Sir Charles Strickland's shell may almost be viewed as a megalomorph, bigger even than the foreign specimens described by Goldfuss and D'Orbigny. It is only right to point out that D'Orbigny describes *Pl. Agassizii* as having the aperture shortened anteriorly, which can hardly be said to be the case with this shell, whose aperture is more like that of *Pl. Hesione,* D'Orb., or of *Pl. Phædra,* D'Orb., which are supposed to represent this group on a higher horizon.

D'Orbigny's *Pl. Agassizii* has been obtained in the Yonne, Haute Sâone, and Charente Inferieure. In the Corallian of Weymouth there is a shell which has more affinity with *Pl. Pelea* (see Damon's Suppl. 1880, pl. xvii. fig 8), having only a single instead of a double row of tuberculations, and being in other respects different to the North Grimston shell. Whiteaves (Ann. and Mag. Nat. Hist. 1861, vol. viii. p. 142 et. seq.) quotes a new species of *Pleurotomaria* allied to *anglica* from the Corallian of Oxford, and somewhat similar forms have been found sparingly in the Coral Rag of other districts.

Genus Patella, Linnæus, 1758=*Helcion,* Montfort and D'Orbigny.

Shells of this genus are particularly scarce from the Corallian rocks of Yorkshire. There are one or two bad specimens in some collections, but the only decently-preserved specimen known to me is the one described below.

54.—Patella rugosa, Sowerby, 1816. Variety. Plate IV. Fig 5.

Patella rugosa, Sowerby, 1816, Min. Conch. t. 139, fig. 6.
Idem. Idem. 1850, Morris and Lycett, Gt. Ool. Moll. p. 89, pl. xii. figs. 1, 1*a-g*.
Patella Mosensis, Buvignier, 1852, Stat. géol. de la Meuse, p. 27, pl. 21, figs. 3-4.

Bibliography, etc.—The type form of Sowerby's species is the well-known and abundant *Patella* from Minchinhampton, of which such forms as *P. Tessoni,* Deslong., may probably be regarded as megalomorphs. With modifications, *P. rugosa* would seem to have an extensive vertical range. *Helcion Rupellensis,* D'Orb. (Prod. de Pal. Strat. vol. ii. p. 12), from the Corallian of La Rochelle, is probably a representative. *P. Mosensis,* Buv., is also a near relative, representing the species on the same horizon in the region of the Meuse. That author describes his species as being near to *P. rugosa,* Sow., from which it is to be distinguished by a sharper apex, finer lines of increase, and less elevation. Buvignier's figure, however, will hardly fit the Yorkshire specimen.

Description.—Specimen from the Coral Rag of North Grimston (Strickland Collection).

Length	25	millimètres.
Width	21·5	,,
Height	? 8	,,

Shell oval, depressed; apex (imperfectly preserved) near the anterior margin. Ornamented with longitudinal radiating ribs, which are fine and wavy, and partly deflected where they are decussated by a few encircling rugose bands. The condition of the specimen scarcely admits of closer description.

Relations and Distribution.—From the bulk of the Minchinhampton specimens this variety is clearly distinguished by the fine and more wavy character of the longitudinal radiating ribs. Still these are not so fine as those shown in Buvignier's figure of *P. Mosensis.*

No instance of any variety of *Patella rugosa* having been found on this horizon in other parts of England is known to me, so that this specimen from the hard Rag of North Grimston is almost unique. An imperfect specimen from the Upper Calcareous Grit of Pickering may belong here.

Order OPISTHOBRANCHIATA, M. Edwards.

This section of the Gasteropoda is so poorly represented, and the specimens are for the most part in such bad preservation, that very little can be said on the subject, which must be disposed of briefly.

Genus BULLA, Klein, 1753.

Shell oval, ventricose, convoluted. Apex perforated. Aperture longer than the shell, rounded at each end, lip sharp.

55.—BULLA (? AKERA) BEAUGRANDI, De Loriol, 1874.

Plate IV. Fig. 6.

Akera Beaugrandi, Loriol, 1874, Loriol and Pellat, Ét. Sup. Jurass. de Boulogne, vol. i. p. 38, pl. vi. fig. 1.

Description. — Specimen from the Coral Rag of Ayton (my Collection).

Length, restored	40 millimètres.
Width across centre	24 ,,

Shell oval, moderately elongate, contracted at either extremity, and slightly tumid in the middle. Spire apparently composed of two or three whorls. The last is very large, and has its surface covered with broad and very marked lines of increase, which, from their prominence and irregularity, produce a certain amount of sculpture on the otherwise smooth surface. The inner lip is broken away anteriorly, and the outer lip so involved in matrix that a closer description is impracticable.

Relations and Distribution.—There is so little to distinguish the various species of *Bulla* from one another that, when, as in this case, a specimen is unique and deeply involved in matrix, some difficulty arises as to its correct identification. *Akera Beaugrandi* occurs in the Pterocérian of the Boulonnais. In outline and proportions, and especially in the broad lines of growth, the Ayton specimen greatly resembles De Loriol's species. Unfortunately, there is no evidence that the anterior portion of the columella is as much excavated as in the type specimen. Buvignier has two species of *Bulla*, viz. *B. Dyonisea*, Buv. (Stat. géol. de la Meuse, p. 28, pl. 21, figs. 25 and 26), and *Bulla Moreana*, Buv. (*op. cit.* p. 28, pl. 21, figs. 33 and 34)—both from the "argile de Kimmeridge" of the Meuse—which also bear some resemblance to the specimen under consideration. The proportions of *B. Dyonisea* especially come very near, but the lines of growth are represented as being fine in that species.

Genus Actæon, Montfort, 1870 = *Tornatella,* Lamarck.

Shell conically ovate, with a conical, many-whorled spire. Spirally grooved or punctate-striate; columella with a long tortuous fold.

Actæonina, D'Orbigny, 1850, is an *Actæon* (*Tornatella*), without plaits on the columella. Cylindrites, Lycett, 1850, is regarded by S. P. Woodward as a subgenus of *Actæon* (cf. Great Ool. Moll. p. 97, and Manual of Mollusca, p. 180). *Section* 1: Shell smooth, slender, subcylindrical; spire small, aperture long and narrow, columella rounded, twisted and directed slightly outwards. *Section* 2: Shell oval, spire sunk, whorls with acute margins. This subgenus is apparently not recognized by continental authors.

56.—Actæon retusus, Phillips, 1829. Plate IV. Fig. 7.

Actæon retusus, D'Orbigny. Prod. de Pal. Strat. vol. i. p. 353, Ét. Oxf.

Bibliography, etc.—Phillips's specimen most probably came from the Lower Calcareous Grit of the coast. The columella in his figure appears more twisted than is the case with the specimen under consideration.

Description.—Specimen from the Coral Rag of Ayton (Leckenby Collection).

Length	19 millimètres.
Width	9 „
Ratio of body-whorl to entire length	76 : 100.

Shell ovately-cylindrical, smooth. Spire composed of four or five whorls, which are tumid, increase suddenly, and are clearly separated by the suture. The height of the body-whorl is three-fourths of the entire shell. In form it is an ovate cylinder rapidly contracting at either extremity. The aperture extends over almost the entire length of the body-whorl, and is narrow posteriorly. The outer lip appears to be rather thick. The inner lip, nearly straight at first, is strongly excavated anteriorly, but scarcely twisted (? *Actæonina*). It projects clear of the columella, which is solid. Anterior portion of the aperture wide. No markings other than fine lines of growth can be distinguished.

Relations and Distribution.—This form is near to *Bulla* (*Actæonina*) *olivæformis*, Koch and Dunker (Nordd. Oolith. p. 41, pl. v. fig. 3), which is said to occur in the Upper "Corallenkalke" of the Middle Oolite along with *Astarte rotundata*, Rœmer, *Melania striata*, Sow., and *Cidarites Blumenbachii*, Goldf.—the very species which are companions of the Ayton shell. Phillips's species is more usually met with in the Lower Calcareous Grit, but it is not common anywhere.

57.—Cylindrites elongatus, Phillips, 1829. Plate IV. Fig. 8.

Bulla elongata, Phillips, 1829, Geology of Yorkshire, vol. i. pl. iv. fig. 7.
Cylindrites elongata, Phillips, 1875, *op. cit.* 3rd ed. p. 260.

Bibliography, etc. — No description has ever been given of this species, and Phillips's figure is turned in such a way as to show nothing of the twist in the columella, which would seem to exclude it from the *Bullidæ.* Those foreign authors who have been bold enough to speculate in this connexion have generally regarded this species as a *Bulla.* Thus Brauns (Ob. Jura, p. 239), in describing *Bulla Hildesiensis*, Rœmer, refers to *Bulla elongata.* De Loriol also (Et. Supr. Jurass. de Boulogne, vol. i. p. 38) appears to conceive that *Bulla elongata* is a true *Bulla*, having certain "rapports" with *Akera Beaugrandi.*

As all the specimens accessible to me are in a wretched state of preservation, I can only suggest that the species in question may belong to the second section of *Cylindrites*, which in the sunken character of the spire and thinness of the outer lip approaches *Bulla.*

Description. — Imperfect specimen, Passage-beds of the Lower Limestones, Scarborough Castle (my Collection).

Length	38 millimètres.
Width.....................................	17 ,,

Shell ovate-elongate, contracted at either extremity, but more so anteriorly. Spire composed of few whorls, smooth, and showing no lines of increase. Shell substance rather thick, except on the outer lip. Aperture long and narrow throughout, but more especially towards the posterior extremity. The excavation of the columella is gradual; near the base it is strongly twisted and directed outwards so as to meet the outer lip with a sharp curve. (N.B.—The anterior extremity of the aperture is broken away in Fig. 8.)

Relations and Distribution. — *Cylindrites elongatus* is excessively plentiful in the Passage-beds and body of the Lower Limestones of the Tabular Hills, where, along with *Gervillia aviculoides*, it contributes largely to the shell-beds of that horizon. It is almost unknown in the Coralline Oolite, and has never, to my knowledge, been found in the Coral Rag. Thus it must be regarded as an Upper Oxfordian fossil, whose representatives should be sought in such beds as the "Oolithe ferrugineuse" rather than in the "Coral Rag" of the Continent.

58.—Cylindrites, sp. Plate IV. Fig. 9.

The specimen figured is from the Coral Rag of Ayton. It represents a form which is of somewhat rare occurrence in the Coral Rag of the Scarborough district. The examples hitherto found are too imperfect to identify or describe. The nearest species is probably *Cylindrites Lhuidii*, Whiteaves. It belongs to the section of *Cylindrites* with a well-developed spire, whereas *Cy. elongatus* belongs, as we have seen, to the section where the spire is sunken.

EXPLANATION OF PLATE IV.

Fig. 1*a*. *Trochotoma tornatilis*, Phillips. Coral Rag of Brompton. Strickland Collection.
,, 1*b*. ,, ,, Same Collection. C. R. North Grimston.
,, 2*a*. and *b*. *Pleurotomaria*, species. Lower Limestones, Wydale. My Collection. Front and back.

Fig. 2*c*. Portion of same magnified.
,, 3. *Pleurotomaria reticulata*, Sowerby. Coral Rag of Settrington Grange. My Collection.
,, 4*a* and *b*. ,, *Agassizii*, Münster. Coral Rag of N. Grimston. Strickland Collection. Back and front.
,, 5. *Patella rugosa*, Sowerby, variety. Coral Rag of N. Grimston. Strickland Collection.
,, 6. *Bulla Beaugrandi*. De Loriol. Coral Rag of Ayton. My Collection.
,, 7. *Actæon retusus*, Phillips. Coral Rag of Ayton. Leckenby Collection.
,, 8. *Cylindrites elongatus*, Phillips. Passage-beds of the Lower Limestones, Scarborough Castle. My Collection.
,, 9. *Cylindrites*, sp. Coral Rag of Ayton. My Collection.

Explanation of Table.

The table annexed contains a complete list of the Gasteropoda entitled to be regarded as species belonging to the Corallian beds in Yorkshire. On referring to the generalized scheme of these beds in the special introduction, pp. 246—247, the various subdivisions are indicated, but a few additional remarks explanatory of the four columns in the table of fossils may be useful.

The basal beds of the Kimmeridge Clay limit the group upwards. The Supracoralline beds, which immediately underlie these, have hitherto yielded such very poor traces of Univalves, that it is not worth while to devote a column to this subformation.

C.R. No. 2.—This is the *Florigemma*-Rag, which girdles the western half of the Vale of Pickering, and overlies the Coralline Oolite of those regions. North Grimston, Langton Wold, Hildenley, Slingsby, etc., have been the most productive localities. Its fauna is fairly similar to that of C.R. No. 1; but where the forms are identical or analogous, they are for the most part finer and larger. Its affinities with the fauna of the Coral Rag at Upware are rather striking—shown perhaps still more in the Conchifera.

C.R. No. 1.—This is the Coral Rag which occupies the inner slopes flanking the Vale of Pickering eastwards from Brompton. Seamer station is the nearest point to Scarborough, distant about three miles. Brompton, Ruston, Ayton and Seamer are the best places for collecting; and as all these villages are within an easy drive of Scarborough, that town is often quoted as the locality for the fossils of this Rag. It is devoid of *Cidaris florigemma*, but contains *Cid. Smithii*.[1]

C.O.—The Coralline Oolite includes the *Chemnitzia*-limestones, and calcareous pastes with Oolite which underlie the Coral Rags throughout the circuit of the Vale. The Oolite at Malton belongs here. Palæontologically it includes the shell-beds connected with the Middle Calcareous Grit, especially the *Trigonia*-beds at Pickering. The subdivision contains a large and varied assemblage of Conchifera, but the Gasteropoda, though individually abundant in some instances, belong to few species.

L.L.—The Lower Limestones constitute an important group or subformation in a stratigraphical sense, and they contain large beds

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[1] There may be some doubt as to whether all the spines of *Cidaris*—for the test is hardly ever met with—really belong to *C. Smithii*, Wright, but no spine which could fairly be referred to *C. florigemma* has been found.

of Oolite, which have been frequently mistaken for the Oolites above the Middle Calcareous Grit. The so-called Coralline Oolite of Scarborough Castle belongs here. Gasteropoda are scarce and badly preserved with few exceptions. The Lower Coral Rag of Hackness is in this series, and the shell-beds on this horizon in other localities (*e.g.* Wydale) have yielded a few specimens.

L C G, Lower Calcareous Grit.

N.B.—The numbers on the left side of the Table refer to species described in the Memoir. v r means very rare; r rare; * moderately plentiful; c, common; v c, very common.

CORALLIAN GASTEROPODA, YORKSHIRE.

	GENERA AND SPECIES.	L.L.	C.O.	C.R. 1	C.R. 2
1	*Purpuroidea nodulata*, Young and Bird	...	...	...	*
2	——— cf. *tuberosa*, Sowerby	...	...	...	r
	——— species	...	...	...	v r
	Murex Haccanensis, Phillips	?			
3	*Natica buccinoidea*, Young and Bird	...	...	...	r
4	——— *Clymenia*, D'Orbigny	...	...	*	*
5	——— *Clytia*, D'Orbigny	...	...	..	v r
6	——— *arguta*, Phillips	...	...	r	r
7	*Chemnitzia Heddingtonensis*, Sowerby	r	v c	c	c
8	——— *Pollux*, D'Orbigny	...	...	...	v r
9	——— *Langtonensis*, Blake and Hudleston	...	...	...	v r
10	——— cf. *corallina*, D'Orbigny	...	...	...	v r
	——— cf. *Clytia*, D'Orbigny	...	...	r	
11	"*Phasianella*" *striata*, Sowerby	...	v c	v c	r
12	*Ph. striata*, var. *Bartonensis*	...	...	..	r
13	*Pseudomelania gracilis*, sp.n.	...	...	r	
14	——— *Buvignieri*, auctorum	...	r	r	
15	——— species	...	...	v r	
16	——— *Leymeriei*, D'Archiac	v r	...		
17	*Cerithium muricatum*, Sowerby	...	c		
18	——— *Russiense*, D'Orbigny	L C G	r		
19	——— near to *limæforme*, Rœmer	...	r	c	*
20	——— near to *grandineum*, Buvignier	...	...	r	
21	——— near to *Humbertinum*, Buvignier	...	...	r	
22	——— *bicinctum*, sp.n.	...	...	...	v r
23	——— *gradatum*, sp.n.	...	r		
24	——— *inornatum*, Buvignier	...	r	c	r
25	*Nerinæa fusiformis*, D'Orbigny	...	?	?	
26	——— *Moreana*, D'Orbigny	...	...	...	v r
	——— *ditto*, Brompton variety	...	...	*	
27	——— species	...	...	v r	
28	——— *pseudovisurgis*, sp.n.	...	v c		
29	——— *Rœmeri*, Phillippi	?	v c	c	c
30	——— species	...	...	...	r
31	——— *Goodhallii*, Sowerby	...	...	...	v r
32	*Alaria bispinosa*, Phillips	L C G	?		
33	*Littorina muricata*, Sow. var. *A.*	L C G	?		
	——— ——— Sow. var. *B.*	...	*	c	*
	——— ——— Sow. var. *C.*	...	...	...	*
	"*Turbo*," cf. *Buvignieri*, D'Orbigny	...	...	r	
	Alaria, cf. *tridactyla*, Buvignier	...	...	...	r
34	*Amberleya Stricklandi*, sp.n.	...	...	r	?
35	——— *princeps*, Rœmer	...	...	...	v r

36	*Neritopsis Guerrei*, Hébert and Deslongchamps	...	...	r	
37	——— *Moreauana*, D'Orbigny	...	...	?	
38	——— *decussata*, Münster	...	...	...	v r
39	*Turbo corallensis*, Buvignier	...	...	r	
40	——— *Erinus*, D'Orbigny	...	...	...	r
41	——— *lævis*, Buvignier	...	...	r	r
42	*Delphinula funiculata*, Phillips	...	r	*	r
43	——— *Pellati*, De Loriol	...	...	...	v r
44	*Trochus obsoletus*, Rœmer	v r			
45	——— *acuticarina*, Buvignier	...	...	...	v r
46	——— *granularis*, sp.n.	...	...	?	
47	——— *Aytonensis*, Blake and Hudleston ...	...	r	r	
48	——— species	...	...	v r	
49	*Trochotoma tornatilis*, Phillips	...	...	c	*
50	*Pleurotomaria*, sp.	v r			
51	——— *Münsteri*, Rœmer	...	*		
52	——— *reticulata*, Sowerby	...	...	...	r
53	——— *Agassizii*, Münster	...	...	...	v r
54	*Patella rugosa*, Sowerby—variety	...	...	...	v r
55	*Bulla Beaugrandi*, De Loriol	...	...	v r	
56	*Actæon retusus*, Phillips	L C G	...	r	
57	*Cylindrites elongatus*, Phillips	v c	?		
58	*Cylindrites*, species	...	...	r	

ERRATA.

Page 295, line 12, *for* 1850 *read* 1852, and similarly where vol. ii.
,, Terrains Jurassiques is quoted.
,, 298, *dele* ,, ,, ,, ,, under the word *buccinoidea*.
,, 394, line 20, *for* fig. 2 *read* fig. 3.
,, 395, ,, 28, ,, fig. 3 ,, fig. 2.
,, 403, last line but one, *for* 3 *read* 2.
,, ,, last line but two, ,, 2 ,, 3.
,, 404, line 12, *for* Rag *read* Oolite.
,, 484, ,, 3, ,, St. Michel *read* St. Mihiel.
,, Idem ,, 21, ,, Verdunense ,, Virdunense.
,, 485, ,, 42, ,, species *read* individual.
,, 488, ,, 1, ,, St. Michel *read* St. Mihiel.
,, 535, ,, 36, ,, Heve *read* Hève.

V.—" PREHISTORIC EUROPE "—SUBMERGED FORESTS AND FOREST-BEDS, CORNWALL.

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

IN Mr. Geikie's admirable work on "Prehistoric Europe," in the chapter "On British Post-Glacial and Recent Deposits," he alludes more than once in very flattering terms to my share in elucidating Cornish Post-Tertiary Geology, at the same time, however, questioning certain conclusions attributed to me with reference to the *general* correlation of the Forest-beds in stream-sections, *i.e.* those resting on the tin ground, with the Forests " exposed *upon the present foreshore.*"

Mr. Geikie says, after sifting the evidence, p. 441 : "I have been unable to discover the grounds upon which it is assumed that the Lower Peat and Trees which rest upon the tin gravels are necessarily synchronous with the submerged forests exposed upon the present foreshore. In some cases this may be the fact, but it is hard to believe, on the evidence produced, that this correlation can be generally sustained." After illustrating his objection by a reference to the Happy Union Section described by Mr. Colenso at Pentuan, he arrives at the conclusion that the ancient forest-bed on the stream-tin-gravels is a relic of an older land surface than that represented by the submarine forests on the present coast-line.

Had I stated that the forest-beds in question were generally correlative with the traces of vegetation from time to time discoverable *on the present foreshore*, I should have committed the egregious error into which Prof. Geikie thinks I have fallen, and that upon the single favourable datum furnished by Mr. Carne's section of Huel Darlington mine in the vicinity of Mounts Bay.

In Post-Tertiary Geology of Cornwall (printed for private circulation in 1879), p. 45, I have stated my views as follows: "The growth of the old forest, the relics of which have been met with all round the Cornish coast, must have extended over a long period of time. The evident connexion of the Mounts Bay Forest with the bed in Marazion Marsh overlying stream-tin, pointed out by Mr. Carne; and the constant presence of a distinct vegetable stratum, or of detritus mixed with vegetable matter, on the tin-gravels in most of the principal sections, points to a *general correlation* of the submerged forests *on the coasts* with the forest-bed in stream-tin sections." I did not anticipate the acceptation of the phrase "submerged forests on the coasts," in the above passage, in so littorally literal a sense as "the submerged forests exposed upon the present foreshore," as Prof. Geikie has rendered it, but meant by it the extensive tract of which these traces between high- and low-water mark are the only observable relics—a tract of the extension of which I have taken (*op. cit.* p. 43) the depths of the stream-tin gravels of Par, Pentuan, Carnon, etc., below the sea-level to be indicative.

I conceive the forests to have flourished over a wide area extending beyond the limits of the present coasts. That this area was of the nature of a great plain broken and stepped by old marine terraces modified by subaerial denudation, and that it was breached by valleys representing the then existing lines of drainage and also clothed with vegetation. As a gradual subsidence narrowed the limits of the forest tract, the sea in its advance would naturally encroach upon the valleys, and if the forest growth continued unimpaired on the plain, and in its inequalities, the lower tracts would of course be first submerged, and their submersion could not be regarded as strictly synchronous with that of the forest belt fringing parts of the foreshore where no such depression existed.

But here again I must guard myself against misunderstanding. I do not think that those parts of the forest which had taken root in the tin ground in the valleys were left in undisputed possession of those positions from their first growth until the access of the sea to their sites (Vide Pleistocene Geology of Cornwall, Part IV. General Notes on Submerged Forests and Tin Gravels, GEOL. MAG. for 1879. "To synchronize the forest remains in the various sections, etc.," and "In like manner the duration of the forest growth, etc.")

Such an idea would postulate the entire desertion of the main drainage lines during the period of forest growth, of the duration of which the Forest-bed in stream-tin sections affords no measure whatsoever.

Take for example the Happy Union Valley. Part of it was at least tenanted by running water, the old forest-bed (to use a relative term) being buried beneath a stratum of silt, probably river detritus, one foot thick; then we have a nearly continuous layer of vegetable matter, probably drifted, and an appearance of silting up and of moss growth, the water being confined to small runlets hardly breaking the continuity of vegetable matter. After this the gradual prevalence of estuarine conditions is evidenced in a bed of silt, which resembles, from the description, as Mr. Geikie points out, the bluish clay so often found beneath the submerged forests on the foreshore. In this silt drift-wood also occurs; but as the top of the bed is about 18 feet below low-water level, it would have been, supposing the growth in situ, subjected to estuarine conditions before the forest belt on the foreshore was buried beneath sea sand; and the vegetable matter corresponding strictly in position with the submerged forest between high- and low-water mark would, as Mr. Geikie points out, occur in the bed of sand 20 feet thick, in which oaks were found lying in all directions, and bones of red-deer, etc.

In Carnon Stream Works, as given by Mr. Henwood (T.R.G.S. Corn. vol. iv.), where human remains were found in association with vegetable matter at 46 feet below low-water, there would appear to be no vegetable representative of the forest growth on the foreshore: but I cannot therefore regard the vegetable bed on the tin ground in this section as representing an older land surface than the submerged forests fringing the coast-line, in any other sense than its position in a depression entitles us to infer—that its growth as a tiny portion of a large forest tract was of less duration than that of portions not similarly situated, and being submerged before the districts at a higher level did not remain a land-surface so long.

The growth of woods on the tin ground soil would be unlikely to lead to the formation of a bluish-grey substratum, such as we find beneath most traces of submerged vegetation on the coasts, resulting from surface decomposition of the Killas, tinged by carbonaceous matter; so that such differences are no doubt due to the accidents of position. Local conditions, however, were so varied as to permit of the formation of a clay soil in certain valleys, Pentuan for example, upon alluvial deposits accumulated subsequently to the destruction of the parts of the forest rooted in the tin ground, and this clay appears to be similar to that which we find beneath those portions of the submerged forest between high- and low-water mark, which doubtless nourished the forestial growth from its beginning to its close over much of the area it originally occupied.

The expression "older land-surface," as indicated by the forest-bed on tin gravels, has been fully explained to me by Mr. Geikie, who kindly furnished me with the following summary of his views, thereby depriving these remarks of any controversial character.

1. Forest-bed on stream-tin gravels = great forest growth: land of wider extent than now.
2. Marine and estuarine beds in stream-tin sections = submergence of land and entombment of trees.
3. Trees and forest-bed in upper part of stream-tin sections, and, probably, submerged forests on foreshore = elevation of land, and re-advance of trees.
4. Beds above 3 = partial submergence.

In the above synopsis Mr. Geikie advocates a recent oscillation by which the dwindling forest growth gained new strength in a comparatively brief respite prior to its final decay; and is inclined to regard the traces of vegetation on the foreshore as relics of the re-growth of the trees upon sites rendered untenable by the previous subsiding movement.

To this I have no objection whatever to urge: on the contrary, it is in conformity with the oscillation advocated by Mr. Godwin-Austen, to account for planed rock reefs at a little above high-water level (Rep. Brit. Assoc. for 1850, Trans. of Sects. p. 71). "Such an oscillation might serve to explain the river sediments gaining on the marine in estuarine stream-tin sections, and to enable them to continue, *pari passu,* with a resumption of the subsiding movement," etc., etc. (Pleistocene Geology of Cornwall, Part V. General Notes, Geol. Mag. for July, 1879).

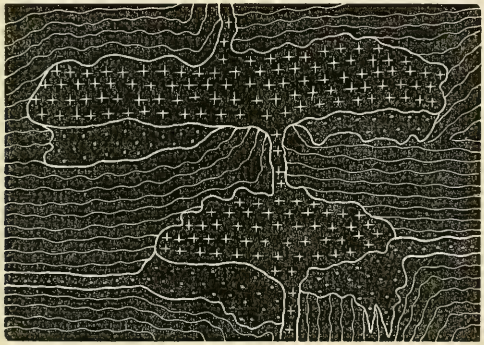
Mr. Geikie's conclusions are based on an extensive knowledge of facts, collated from all quarters, and which, I need hardly say, were beyond my range. I could only advocate the probability of an oscillation of a few feet, as suggested by Mr. Godwin-Austen, so that from so restricted a point of view I could not regard the re-elevated foreshore as favourable to the growth of trees. I do not, however, think, as regards Cornwall, Devon, and Somerset, that the elevation hinted at might not, without militating against facts, be made sufficiently elastic to have converted the shallows of such coasts as Mounts Bay into dry land, and have continued long enough, not only to arrest the decay of the surviving forests in inland localities, but even to permit of their re-growth upon deserted foreshore sites, and to give colour to the tradition of "Caraclowse in Cowse, in English the hoare rock in the wood," as applicable to St. Michael's Mount.

In conclusion, I must plead necessity for recurring at such length to this subject, at the same time expressing my thanks to Mr. Geikie for affording me the opportunity of explaining, more fully, views which the general tenor of my classification, as expressed in my papers on Cornish Post-Tertiary Geology, may have left somewhat ill defined, as it was foreign to my purpose to discuss at length the changes indicated by the details of individual stream-tin sections.

VI.—Laccolites.

By G. H. Kinahan, M.R.I.A.,
President of the Royal Geological Society of Ireland.

In the Report on the Geology of the Henry Mountains, Rocky Mountain Region, Mr. G. K. Gilbert, of the U.S. Geographical and Geological Survey, points out that many of the intrusions of eruptive rocks now exposed had a deep-seated origin; the molten rock having filled vacancies in the rocks, and never coming to the surface until they were exposed by denudation or by faults. To quote our author, "The lava . . . instead of rising through all the beds of the earth's crust, stopped at a lower horizon, insinuated itself between two strata, and opened for itself a chamber by lifting all the superior beds. In this it congealed, forming a massive body of trap." For these masses of eruptive rocks, Gilbert proposes the name *laccolite* (Gr. lakkos *cistern*, and lithos *stone*). In the Cos. Wexford and Wicklow some of the protrusions of eruptive rocks are entitled to this name, the rocks having congealed in cisterns below the surface of the earth; there are, however, some marked differences between them and the laccolites of the Henry Mountains. The latter were intruded into nearly horizontal strata, the laccolites only consist of one kind of rock, while the adjoining rocks seem to have been very little altered. But the Wexford and Wicklow laccolites, on the other hand, were intruded into highly disturbed strata, they are made up of a variety of rocks, and always the aquo-igneous action due to their intrusion—"baked" or altered, a greater or less thickness of rocks about them.



Vertical section of a Laccolite in contorted strata.

〰〰〰 Baked rocks.

\+ + + + Molten rocks } of Laccolite.

. · . · . Fragmentary rocks } of Laccolite.

The distance to which the "baking" has extended is very variable, on account of the ends, not the planes, of the differently composed beds being in contact with the eruptive rocks; rocks of different characters and composition being differently susceptible; consequently, in regard to their composition, some have been more altered in depth and quality,—few apparently being ever changed into gneissoid and granitoid rocks.

The rocks in the more marked laccolites are usually gabbros or allied eurites, that graduate into granitoid, and allied basic elvans; but sometimes there are also felstones with their allied elvans. Associated with these normal intrusive rocks are others of fragmentary character, like agglomerates and other tuffs. Such mechanically formed rocks are usually supposed to be accompaniments of surface accumulations; a little consideration, however, will show that it is not only possible but even highly probable that they accompany the formation of some laccolites.

In order that a laccolite may be formed in a particular place, some favourable conditions must exist at that place. During the disturbances of the strata, such has taken place in the Cambro-Silurian rocks of Wicklow and Wexford, the horizontal jamming of one or more breadths of rock against each other would make them tend to rise and yield more readily to the pressure of the molten mass injected beneath. In some cases they might rise even independently of this pressure, leaving a vacancy under them, inviting the ingress of the lava; such hollows might sometimes be enlarged by the gases being forced into them under high pressure, the gases blowing in, out of the passages, loose fragments of the rocks in addition to those carried in on the molten matter; and all brought into the chamber, either by the force of the gas or by the molten matter, be driven into the cracks or other vacancies, or be lifted up on the surface of the latter.

The general character of the laccolites under consideration seems to be this—their principal mass or nucleus is composed of intrusive rocks, while on these and filling interstices in the "baked rocks" are these fragmentary rocks, while "baked rocks" envelope all. Sometimes, however, these fragmentary rocks extend away into the "baked rocks." An explanation for these also may be suggested; open fissures existed between beds of strata or across them, all of which had to be filled; into those that terminated either upward or lengthways the fragmentary matter was blown and forced to remain in them, while if the fissure led to another cistern or to the surface, the fragmentary matter would be forced through or carried out of it; thus we should have dykes of the normal rocks of the laccolite leading from one to another, while on these normal rocks and in dykes or in apparently interbedded masses leading away from them, we should find their fragmentary adjuncts.[1]

The fragmentary rocks associated with the gabbros are often highly calcareous. In many cases they are an agglomerate containing limestone concretions; and in some places there are masses of such agglomerates that appear to be independent laccolites, the rocks surrounding them being baked; in some places it is evident that small masses of such fragmentary rocks must have been protruded into their present positions.

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[1] Gilbert mentions as adjuncts to his laccolites "dykes and sheets"; these, however, are filled with a rock the same as the laccolites, while in Wexford and Wicklow the dykes and sheets often seem to be fragmentary rocks.

REVIEWS.

I.—A MONOGRAPH OF THE SILURIAN FOSSILS OF THE GIRVAN DISTRICT IN AYRSHIRE. By H. A. NICHOLSON, and R. ETHERIDGE, jun. Fasc. III. 8vo. pp. i.–vi., 237—341, and Plates xvi—xxiv. (London and Edinburgh, Blackwood, & Co., 1880.)

BESIDES descriptions of *Serpulites* and various so-called Worm-tracks (which are here carefully treated as having been probably due to Crustaceans and other creeping and burrowing animals besides Worms), the Asteroid and Crinoid Echinodermata, found in the Silurian rocks of Girvan, are published in this Part of Nicholson and Etheridge's excellent Monograph. It contains also some of the intended Supplements descriptive of (1.) *Clathrodictyon* and *Hyalonema* (?), but why the latter should be regarded as a Rhizopod is not clear; (2.) *Heliolites*, *Plasmapora*, *Propora*, *Pinacopora*, *Halysites*, and *Favosites*, among the Tabulate Corals; (3.) *Staurocephalus*, *Cyclopyge*, *Trinucleus*, *Dionide*, and *Agnostus*, among the Crustacea; with (4.) the cirripedal *Turrilepas*. See also GEOL. MAG. No. 177, p. 135; and No. 189, p. 139.

These additions are chiefly based on a large amount of new material collected by Mrs. Gray and others in the Girvan district; and are partly due to information accruing in the course of the work.

The printing and paper are of the first quality, and the plates are also good. An index to the first volume, now completed, is given in this Fasciculus; and great credit is due to the authors for these good results of their persistent and enthusiastic labour, supported by a Royal Society Government Grant.

II.—REVUE DE GÉOLOGIE, POUR LES ANNÉES 1877 ET 1878. PAR MM. DELESSE ET DE LAPPARENT. (Paris, F. Savy, 1880.)

FROM the preface to the sixteenth volume, it would appear that this useful publication will now be brought to a close. During sixteen years, under the able editorship of M. Delesse associated with M. Langel in the first three numbers, and with M. de Lapparent in the continuation (vols. 4 to 16), this work has contained a concise account of the contents of the numerous papers connected with geology, and the allied sciences, during that period. The present volume records the progress of geology during the years 1877–78, and like the preceding ones, the subjects are arranged under five heads: Physiographic, Lithological, Historical, Geographic, and Dynamic Geology.

Among the various papers collated, special attention has been given to the new researches on lithology, metamorphism and the analysis of rocks, as also to agricultural geology. The sixteen volumes will form a very important, if not an indispensable work of reference for the geologist, in which the authors have endeavoured to continue the useful work of M. d'Archiac, by giving, year by year, the principal facts bearing on the progress of the science.

J. M.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—Jan. 19, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Further Notes on the Family *Diastoporidæ*, Busk." By G. R. Vine, Esq. Communicated by Prof. P. Martin Duncan, M.B. Lond., F.R.S., F.G.S.

In continuing his review of the family of the *Diastoporidæ*, the author stated that upon the question of the classification of the Polyzoa he is inclined to accept the views recently published by the Rev. T. Hincks, in preference to the earlier one enunciated by Prof. Busk. He now described the forms found in the Lias and Oolite, including *Diastopora stromatoporides*, Vine (= *liassica*, Quenst.), *D. ventricosa*, Vine, *D. oolitica*, Vine, *D. cricopora*, Vine.

The author then proceeded to argue against the inclusion of the foliaceous forms in the genus *Diastopora*, and concluded by giving a definition of the genus, as now limited by himself.

2. "Further Notes on the Carboniferous Fenestellidæ." By G. W. Shrubsole, Esq., F.G.S.

The author pointed out the discrepancies in the descriptions given by Lonsdale, Phillips, M'Coy, and King of the genus *Fenestella*, as represented in the Silurian, Devonian, Carboniferous, and Permian formations respectively. He then proposed a new definition of his own, and described the following species:—*F. plebeia*, M'Coy, *F. membranacea*, Phil., *F. nodulosa*, Phil., *F. polyporata*, Phil., *F. crassa*, M'Coy, *F. halkinensis*, sp. nov.; and in conclusion he pointed out that the few species to which he has reduced the Carboniferous *Fenestellæ* find their representatives in the North-American continent, only one really new form, *F. Norwoodiana*, having been described there.

II.—February 2, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Coralliferous Series of Sind, and its connexion with the last Upheaval of the Himalayas." By Prof. P. Martin Duncan, M.B. Lond., F.R.S., F.G.S.

This communication is the result of the author's study and description of the fossil corals of Sind, undertaken at the request of the Geological Survey of India. The history of the researches in the geology of the Tertiary deposits of Western Sind was noticed in relation to a statement made some years since by the author and Mr. H. M. Jenkins, F.G.S., that there was more than one Tertiary series there, in opposition to both D'Archiac and Haime.

After a brief description of the geology of the Khirthar and Laki ranges of hills, which were called Hala Mountain by the French geologists, the succession of the stratigraphical series demonstrated by the survey under Blanford and Fedden was given, and the author proceeded to discuss the peculiarities of the six coral faunas of the area, and to argue upon the conditions which prevailed during their existence. A transitional fauna, neither Cretaceous nor Eocene, underlies a trap: to the trap succeeds a great development of Nummulitic beds, containing corals, the Ranikot series, some of which are gigantic representatives of European Nummulitic forms. A third fauna, the Khirthar, succeeds, and a fourth, Khirthar-Nari, which was a reef-building one; and a fifth, the Nari, is included in the Oligocene age. An important Miocene coralliferous series (the Gaj) is on the top of all. These faunas above the trap are Nummulitic, Oligocene and Miocene in age, and in the first two European forms, which are confined to definite horizons, are scattered indefinitely in a vertical range of many thousands of feet. The corals grew in shallow seas, but most of them were not massive limestone builders, but there were occasional fringing reefs, or rather banks of compound forms, which assisted in the development of limestones. Many genera of corals, which elsewhere are massive, are pedunculate in Sind, and the number of species of the family Fungidæ is considerable. There are also alliances with the Eocene coral fauna of the West Indies.

The depth of the coralliferous series and the intercalated unfossiliferous sandstones, etc., is, according to the Survey, 14,000 feet, without counting an estimated 6000 feet of unfossiliferous strata in one particular group. The subsidence has therefore been vast, but not always continuous.

After noticing the numbers of genera and species in this grand series of coral faunas and the remarkable distinctness of each, the author proceeded to discuss the second part of his subject. When President of the Society, he had stated in his Anniversary Address for 1878, that he was not convinced of the truth of the theory of the Geological Survey of India regarding the Pliocene age of the last Himalayan upheaval. The considerations arising from the position of a vast thickness of sedimentary deposits overlying the Gaj or marine Miocene, and containing *Amphicyon, Mastodon, Dinotherium,* and many Artiodactyles of the supposed pig-like ruminant group, lead to the belief that the author was not justified in opposing the theory enunciated by Lydekker and the Directors of the Survey. The position of these Manchhar strata on the flanks of the mountain system of Sind was compared with that of the sub-Himalayan deposits. The faunas were compared, and the Sewalik deposits, the equivalents of the Upper Manchhar series of Sind, were pronounced to be of Pliocene age. They were formed before and during the great upheaval of the Himalayas, and in some places are covered with glacial deposits.

A comparison was instituted between these ossiferous strata and the beds of Eppelsheim and Pikermi, and the author discussed the question relating to the age of terrestrial accumulations overlying marine deposits.

2. "On two new Crinoids from the Upper Chalk of Southern Sweden." By P. H. Carpenter, Esq., M.A. Communicated by Prof. P. Martin Duncan, M.B. Lond., F.R.S., F.G.S.

Stem-joints of a Crinoid resembling those of *Bourgueticrinus* have long been known in the Plänerkalk of Streben (Elbe); but on the discovery of the calyx it was found to differ considerably from that genus. It was then referred to the genus *Antedon* by Prof. Geinitz. Stems also resembling *Bourgueticrinus* have been found in the Upper Chalk of Köpinge (S. Sweden), and a calyx resembling that described by Prof. Geinitz has also been found. Prof. Lundgren kindly entrusted this to the author for description.

For these two fossils he considers not only a new genus but also a new family required. He proposes for the former the name *Mesocrinus*, as the characters of its calyx ally it to the Pentacrinidæ. The author describes the characteristics of the genus *Mesocrinus* and of the species *M. suecica* (the Swedish) species, and its differences from *M. Fischeri* (from Streben), and discusses the relationships of the genus, which combines the characters of a *Pentacrinus*-calyx with a *Bourgueticrinus*-stem.

A new species of Comatula (*Antedon impressa*) from the Ignaberga Limestone of Scania was also described, and its systematic position discussed.

Dr. Otto Hahn, of Reutlingen, exhibited a large series of Microscopic sections of Meteorites, in explanation of which the following remarks were addressed to the President and Fellows present:—

"Dr. Hahn, in inviting you to examine the microscopical specimens of meteorites which he has prepared, and in order to assist you in determining the character of the forms and structures which you will find exhibited in them, desires to present a short summary of the negative considerations which forbid that such structures should be classed among crystalline forrms.

"As is well known, the *chondrites*, the species of meteorites from which his specimens are prepared, consist, besides the metals which they enclose, of the minerals enstatite and olivine.

"In his work on the meteorites and their organisms, lately published, Dr. Hahn has given photographs of 130 different forms and structures. Now if these structures are crystalline, the two minerals in question would present themselves in at least 130 different forms and structures, although the absence of all structure is recognized as a fundamental principle of the theory of minerals.

"Again, the structures exhibited by the chondrites cannot be due to slaty cleavage, since olivine has no slaty cleavage, and that of enstatite and of other minerals does not appear under the microscope, or else presents itself there under totally different forms.

"The greatest importance, however, is to be attached to the total absence of all polarized light exhibited by the two minerals as occurring in the meteorites. The contained forms and structures do not polarize the light at all, or only very feebly, although the same minerals, under ordinary circumstances, polarize light very strongly. The absence of all aggregate polarization is especially noticeable, as proving that these objects are not aggregates of crystals.

"Should we still feel inclined to regard the enclosures as mineral forms, and not as organisms, we must be struck by the utter absence of all crystalline forms, especially in those very minerals which always, and occasionally also in meteorites, appear in a crystallized form.

"Further, the external forms, and consequently the outlines of the enclosures, harmonize so perfectly with their internal form and structure, that we cannot entertain the idea that these enclosures had been rolled about and ground down before they became finally imbedded in the chondrites.

"The idea of an aggregate of crystals, if still looked upon with favour, would be contradicted by the fact that the enclosed balls or globes are all constructed excentrically, whereas all terrestrial crystallites are formed concentrically."

CORRESPONDENCE.

STROMATOPORA AND CAUNOPORA.

Sir,—In the August (1880) Number of the Geological Magazine, which owing to some error of transmission has come to hand only a few days ago, I observe an interesting paper by Dr. F. Roemer, on the relation sometimes observed between the growth of *Stromatoporæ* and tubular corals; and which in some formations in this country is so common as to have been regarded as a sort of "commensalism." I have referred to these cases in my paper on *Stromatoporidæ* in the Journal of the Geological Society for February, 1879, as well as to other perforations, probably due to the operations of some boring animal. While, however, some specimens of these kinds may have been referred to the genus *Caunopora,* it would be unfortunate if palæontologists should suppose that all the fossils of that genus are of the character in question. It will be seen by reference to the paper above cited, that such *Caunoporæ* as my *C. Hudsonica*, as well as *C. incrustans* and *C. planulatum*, Hall, not only have vertical canals which are essential parts of their structure, but that these canals send forth radiating tubes into the substance of the thickened laminæ. Of the *Stromatoporidæ* with such vertical canals there are two types, which I have referred respectively to the genera *Caunopora* of Phillips, and *Cœnostroma* of Winchell: the former having single vertical tubes, the latter groups of such tubes. In America both genera begin in the Niagara formation and extend upward to the Chemung, or from the lower part of the Upper Silurian to the upper part of the Erian or Devonian. J. W. Dawson.

McGill's College, Montreal.

ON CERTAIN CASES OF THE OUTCROP OF STRATA.

Sir,—As the Rev. O. Fisher's allusions to Spherical Trigonometry in your January Number may sadly perplex many accomplished geologists, who have not made a special study of higher mathematics, I venture to enclose a simplified explanation of his results.

First, as regards the delineation of cylindrical surfaces exposed in plane sections, the ordinary rule of 'foreshortening,' as taught in all Schools of Art, will amply suffice.

I have found in practice that a shadow cast by sunlight on a paper properly inclined gives the true result most simply. It is, however, worthy of remark that the outcrop of a cylindrical stratum on a plane surface cannot differ from the outcrop of a plane stratum on a cylindrical hill, or in a hollow cylindrical valley; and is therefore reducible to "Sopwith's models."

Next, in assuming that the trail outcrop had a definite direction on either side of the railway cutting, does not Mr. Fisher assume that the trail lies in one plane?

Under these circumstances a straight rod placed at the one outcrop parallel to the other outcrop satisfactorily determines the strike and dip of the stratum.

As regards the equation $\tan\phi = \cos\beta \tan\alpha$ (2)

I subjoin a short proof.

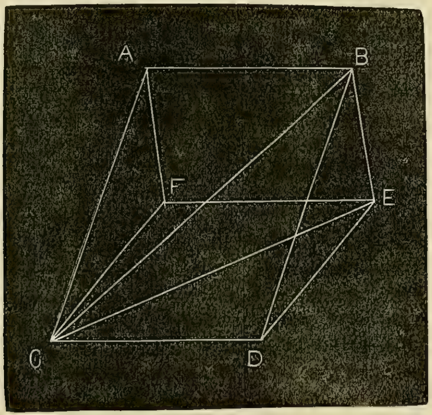
Let AB CD be horizontal (strike) lines in the inclined plane.

BE vertical, CDE a horizontal plane.

$$\text{Then } \angle\, BCE = \phi$$
$$BDE = \alpha$$
$$CED = \beta$$

Also CDE is right angle.

$$\text{Hence } \tan\phi = \frac{BE}{CE} = \frac{BE\cos\beta}{ED}$$
$$= \tan \quad \cos\beta$$



H. G. DAY, M.A.

THE PRE-CAMBRIAN ROCKS OF BRITAIN AND BOHEMIA.

SIR,—In Dr. Callaway's letter on this subject (GEOL. MAG. Feb. 1881), there are some passages which are to my mind a little misleading in regard to the Dimetian rocks at St. Davids. The main portion of the group consists of what appears to be a massive granitoid rock, but on closer examination traces of foliation are abundant. Indeed, throughout the whole group there is a schistose character developed, so that in consequence the most massive portions are found to be utterly worthless for dressing, either for building or paving purposes. This fact, though a species of rough evidence, is found to be very valuable in distinguishing many of the metamorphic rocks from those of igneous origin. In the latter the even admixture of the constituents and the regular crystallization enable them to be readily dressed in blocks, whilst the former, except where they consist of limestone or such-like sediments, are seldom sufficiently even in character through any thickness for this purpose. Hence the intrusive granites, greenstones, and various lava flows are frequently used for building and paving purposes, but the metamorphic rocks but seldom. The term gneissic or schistose may certainly be applied to the St. Davids Dimetian rocks throughout, but perhaps more especially to the middle portion of the group, seen in the valley between the Camp and Ponthclaish. Here the beds are usually less massive than at the base, or in the upper or more quartzose portion, and on very slight weathering the foliated character is very marked. Thin lines of nearly pure white felspar are also common, and a tolerably clear gneissic appearance exhibited.

It must not be expected that in these attempts at correlation anything like an absolute identity in character can be found in different areas. Certain general resemblances in mineral character, combined with the physical evidences indicative of contemporaneous deposition, are all we can expect, especially if, as I presume, I may take for granted, that most will now allow that these metamorphic rocks must have had at first an aqueous origin, and were deposited in successive layers of various materials like the alternating sediments found in more recent groups. If we examine closely any of the unaltered groups, capable of being correlated by their fossils, we readily recognize some general mineral resemblances over very considerable areas, and Mr. Marr has particularly referred to some of these in his very excellent and highly suggestive paper. But there are, on the other hand, many minor differences, and this is especially the case where the sediments have been deposited in rather shallow water. For instance, the Harlech group at St. Davids and in the Harlech mountains is mainly composed of sandstones, whilst in Carnarvonshire it consists chiefly of slates, and in the north-west of Scotland of conglomerate and grits. Now if we suppose, as I believe was the case, that the Dimetian group was chiefly deposited in shallow water, the differences so well marked in the unaltered rocks of the Harlech group are exactly those which would, under the influence of metamorphism, produce a massive granitoidite at one place, a quartzose gneiss or micaceous schist at another, and yet a general resemblance indicating the prevalence of tolerably similar physical conditions at the time would be retained in the group in each area.

On these considerations I think Mr. Marr was fully justified in classing the quartzose gneisses of Bohemia with the Dimetian rather than with any other known European Pre-Cambrian group, especially as he found them overlaid unconformably by rocks similar to those found in the Pebidian group. Certainly from his descriptions they could not be classed with the dark hornblendic and red gneisses which the Scotch geologists have invariably claimed to be characteristic of the Hebridean or Lewisian group. Moreover, the very fact that most of the gneisses in the central highlands were found, like the Dimetian of Wales, to be highly quartzose in character, formed one of the chief stumbling-blocks to their being recognized as of Pre-Cambrian age: even Nicol found this a difficulty. Now, however, since the Dimetian rocks in Wales have been recognised, this need offer no difficulty in future, and I feel convinced that ere long the Dimetian and Pebidian groups will be as easily separated from one another even in Scotland as has been the case now in Bohemia through Mr. Marr's researches.

HENDON, N.W., *Feb.* 7, 1881. H. HICKS.

DISTURBANCES IN THE CHALK OF NORFOLK.

SIR,—I am indebted to Mr. H. B. Woodward for pointing out that Mr. J. E. Taylor was subsequently inclined to suggest a different age and cause for the disturbance at Whitlingham. This had escaped my notice, but supposing that Mr. Taylor's later view, now endorsed by Mr. Woodward, is correct, it does not follow that all disturbances of the Chalk in Norfolk are due to the same cause. The passage of ice has no doubt disturbed and broken up the Chalk in many places; but I still submit that it is difficult to conceive of any *surface* agency being capable of producing such a sharp contortion in a solid scar of chalk like that at Trimmingham.

A. J. JUKES-BROWNE.

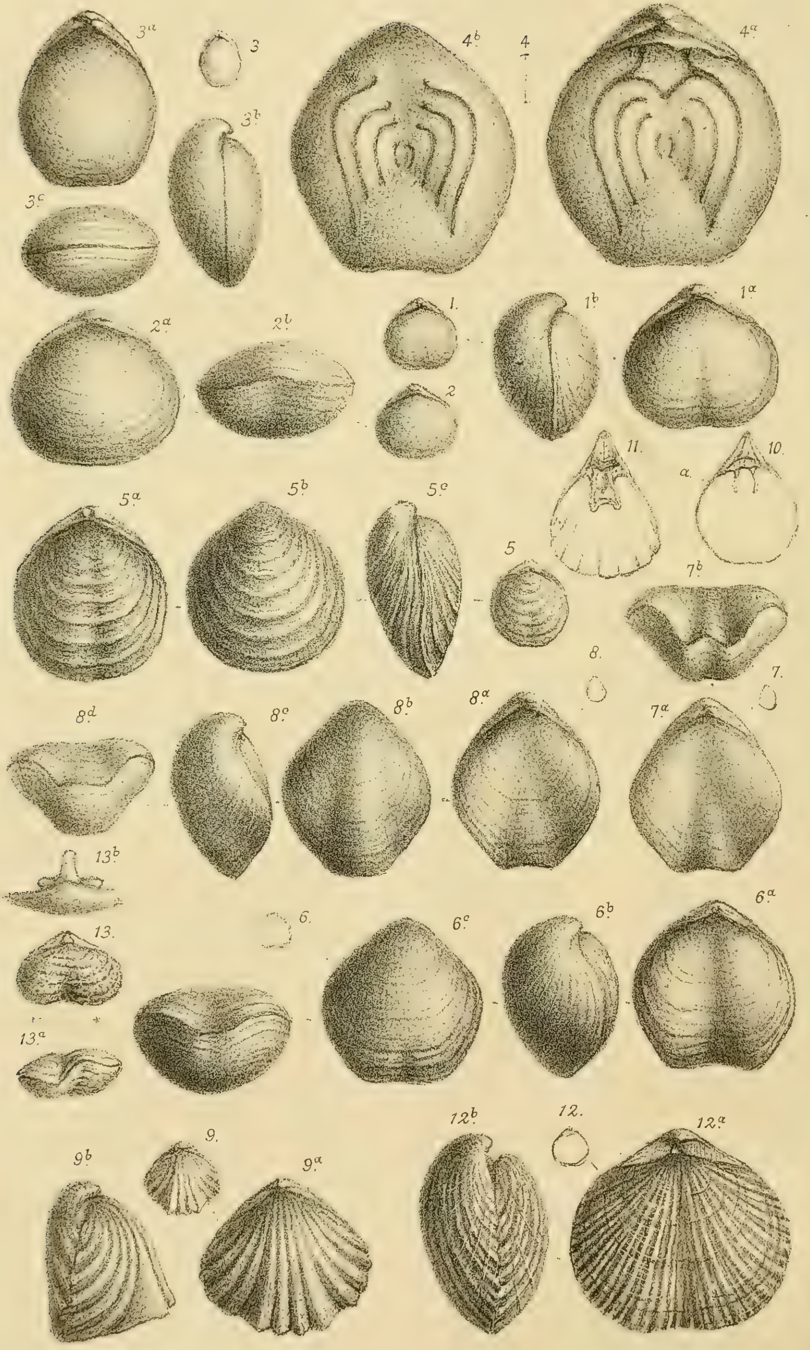
HIGHGATE, *Feb.* 4.

SHRINKAGE FISSURES.

SIR,—I would direct the special attention of geologists to the chasms due to the subsidence in Cheshire; of which an excellent sketch recently appeared in the *Graphic*. From these shrinkage fissures we learn how gorges or cañons can be made without denudation—because if such a small thing as the vacancy in a salt mine produces such marked results, how much greater must be the results from vacancies caused by vulcanicity and other natural phenomena? The sketch has an aspect very similar to some of the maps of cañons in Dr. Hayden's magnificent reports.

G. H. KINAHAN.

WE regret to record the death of two well-known and highly-esteemed geologists, namely:—Dr. J. J. BIGSBY, F.R.S., F.G.S.; and Prof. JAMES TENNANT, F.G.S. Notices of these veterans will be given next month.



Thos. Davidson del & lith.

M&N. Hanhart imp.

U. SILURIAN BRACHIOPODA.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VIII.

No. IV.—APRIL, 1881.

ORIGINAL ARTICLES.

I.—Descriptions of New Upper Silurian Brachiopoda from Shropshire.

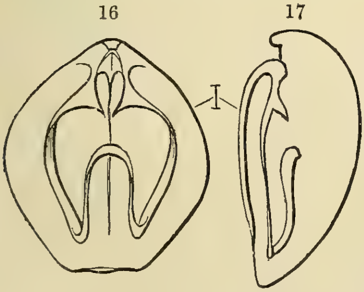
By Thomas Davidson, F.R.S.

(*Concluded from p.* 109.)

(PLATE V.)

1. *Waldheimia? Mawei*, n. sp. Pl. V. Figs. 7, 8.

SHELL small, marginally sub-pentagonal, longer than wide, straight or slightly indented in front. Dorsal valve laterally gently convex, longitudinally concave, with a small median rib commencing at about the middle of the valve, and widening as it nears the front. Ventral valve very convex and keeled along the middle or divided longitudinally by a groove commencing at about half the length of the shell and extending to the front. Beak small, incurved, foramen minute, beak ridges strongly marked. Surface of valves smooth. In the interior of the dorsal valve, under the hinge-plate, a slightly elevated longitudinal septum or ridge extends to within a short distance of the frontal margin. To the hinge-plate are attached the principal stems of the loop, which, after giving off crural processes, extend to within a short distance of the front, where they become reflected so as to form the loop. Length 2, breadth $1\frac{1}{2}$, depth $\frac{1}{2}$ line.



Waldheimia Mawei, Dav. *Developed by Rev. N. Glass.*

Obs.—This small shell was procured in some abundance from the washings of the "Tickwood Beds," or Upper Wenlock Shales, from under railway bridge at Farley Dingle, also from the upper part of the Wenlock Shale, below limestone, water course, under Benthall Edge, and opposite Ironbridge in Shropshire.

Having placed in the hands of the Rev. Norman Glass a number of specimens filled with a light-coloured semi-transparent spar, he was able, after much trouble and patience, to develope the loop in several specimens, and in the clearest possible manner, and so like in general character is this loop to that of *Waldheimia* that I have provisionally placed it with that genus. Exteriorly this small species bears so much general resemblance to some forms of *Centronella*, and in particular to *C. Hecate*, Billings (Canadian Journal, May, 1861, p. 63), that previously to having been made acquainted with its loop I had placed the new English species in Billings' genus. *Centronella* is described by Prof. J. Hall (Sixteenth Annual Report of the Regents of the University of New York, p. 45, 1863) as consisting of two delicate riband-like lamellæ, which extend to about half the length of the dorsal valve. "These lamellæ at first curve gently outwards, and then approach each other gradually, until at their lower extremities they meet at an acute angle; then becoming united, they are reflected backwards towards the beak in what appears to be a thin flat vertical plate." Now our small species does not show these characters, for in all the specimens developed by the Rev. N. Glass the extremities of the principal stems do not converge so as to become united at their lower extremities, but are wide apart, and instead of extending to only half the length of the shell, are prolonged to within a short distance of the frontal margin. The loop is not therefore that of *Centronella* as described by Billings and Hall. The genus *Waldheimia* had not hitherto been quoted as far down as the Upper Silurian. *Terebratula* and *Centronella* had been so, and we now know that species with short and long loops commence to appear in the Upper Silurian period.

2. *Waldheimia ? Glassei*, n. sp. Pl. V. Fig. 6.

Shell small, sub-pentagonal, broadest posteriorly, slightly truncated in front. Dorsal valve slightly convex, curving rather abruptly at the lateral margins, with a median longitudinal groove or depression, commencing about half the length of the shell, and extending to the front, beak incurved, truncated by a small foramen, hinge-ridges well defined, surface of valves smooth, marked by concentric lines of growth. Length 3, breadth 3, depth 2 lines.

Obs.—About fifteen examples of this species were obtained by Mr. Maw from the washings of some seven tons weight of Buildwas Lower Wenlock Shales. All the specimens procured were of about the same dimensions, none exceeding the measurements above given. Only very few of them were in a perfect state of preservation, and none were in a suitable condition for Mr. Glass's operations, consequently all his endeavours to develope its interior characters proved unsuccessful. It is a rather larger shell than *Waldheimia ? Mawei*, but bearing some resemblance to it in external shape; this has prompted me to leave it provisionally with that genus. Perhaps it may possess the interior characters of *Centronella*, and it will be very desirable to procure specimens suited to Mr. Glass's operations.

3. *Atrypa reticularis*, Linné sp.

At p. 9 of this paper I alluded to the interior characters of this abundant species. Having, thanks to Mr. Maw's liberality, been able to examine upwards of eight thousand specimens of the species from the Wenlock and Ludlow rocks of Shropshire, I have ascertained how much it varies in shape, and especially so at different stages of growth. The smallest or youngest examples measured not much more than half a line in length and breadth, and every stage was obtained up to shells measuring one inch and a half in length and breadth. When quite young the dorsal valve is flat or nearly so, with a strongly-marked longitudinal mesial depression; this same valve with age becomes gradually more and more convex or gibbous, and loses gradually all trace of the longitudinal depression.

The front line is also either straight or more or less curved upwards, so much so that many specimens show in the dorsal valve a well-developed mesial fold, with a corresponding sinus in the ventral one. The ribbing varies also to a very considerable extent in different specimens. In young individuals the ribs are few in number, and in this condition it much approaches in shape and character to similar-sized examples of *Atrypa Barrandi.* The number of ribs seems also to increase rapidly with age. Some specimens with very convex dorsal valves are covered with numerous fine radiating ribs, while others of the same size show a much smaller number, and these more coarse and prominent. The concentric lines or squamose ribs due to growth are also much stronger, closer, or more wide apart in some individuals than in others, still all these individuals are linked one to the other by gradual passages. Feeling anxious to ascertain whether there existed interiorly any gradual increase in the number of spiral coils from the young up to the adult condition, I placed in the hands of the Rev. N. Glass a number of well-preserved specimens at different stages of growth, and some of which he kindly developed with his usual ability, and he was soon able to show, and in the most distinct manner, that the number of coils in each of the vertical spiral coils increased with the growth of the shell. In a specimen measuring four lines in length and breadth there were only five convolutions in each spiral cone, and these specimens much resemble those of *Atrypa Barrandi*, and in all probability, if not certainly, in still younger specimens Mr. Glass would have found not more than three or four coils.

In a specimen measuring five lines in length he found six coils, in another six lines in length seven coils, and so on no doubt the increase would proceed up to fifteen convolutions in each spiral—the usual number found in full-grown specimens. Mr. Glass ascertained likewise that the basis of the spiral cones in young specimens with flattened dorsal valves is not level, the two inner sides of the principal coils being slightly higher than the two outer sides, and turned towards the margin of the shell—which is exactly what we have described and represented in *Atrypa marginalis* and *Atrypa Barrandi*, the dorsal valves of which are also nearly or quite flat (see pp. 10 and 11 of this paper). As the shell grows, and the dorsal valve becomes more convex, the basis of the spirals becomes more level, and the spiral cones more elevated, as we have figured them in p. 9 of this paper. The principle of the variation of shape in the spirals of certain genera and species of the *Atrypidæ*, seems to be the providing of such a form of spirals as should allow the greatest length of coil possible in the interior of the shell; for example, in *Glassia obovata* and *G. elongata* the ventral valve if anything is slightly more convex than the dorsal, and consequently the spirals are slightly more convex on the ventral side, and the length of the coils on that side is still further increased by the notch or indentation on the ventral slope of the posterior border of the spirals. Again, as we have just seen, in *Atrypa marginalis*, *A. Barrandi*, and in the young specimens of *A. reticularis*, the dorsal valve is nearly or quite flat, and this being the case there are several differences between their spirals and those in the full-grown specimens of *A. reticularis*, the dorsal valve of which is ventricose. First, there are a fewer number of spiral coils, but to allow space even for these some changes were necessary in the arrangement of the spirals, and therefore the principal coils instead of being level are slightly higher on their inner than on their outer sides, whilst, unlike the majority of the full-grown specimens of *A. reticularis*, the principal coils are some little distance apart, and the ends of the spirals bend over to meet each other. It will be seen at once that these peculiarities in the arrangement of the spirals (the coils being only few in number) make them on their dorsal side to be almost level, and suitable, therefore, to the interior space which they have to fill.

Through the kindness of Mr. R. P. Whitfield, Mr. Glass and myself have been able to examine the only developed American example of Prof. Hall's *Cœlospira disparialis*, from the collection of the American Museum of Natural History, New York, and we are able to assert that its characters and spirals are so exactly similar to those of *Atrypa Barrandi*, that we are strongly inclined to consider them as belonging to the same species, and both as referable to *Atrypa*. I have added these details to show how important it is to study the gradual development of a species from its youngest to its full-grown condition.

4. *Glassia obovata*, Sow., sp. Pl. V. Figs. 1, 2.

Atrypa obovata, Sow., Sil. sp., pl. viii. fig. 9, 1839.

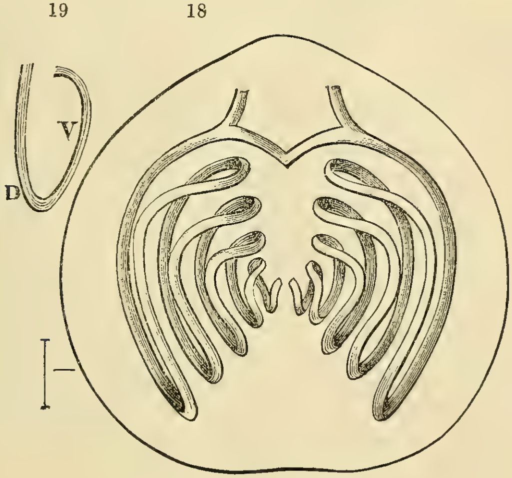
We have already described the interior and character of this species. It is variable in shape, the valves being nearly equally and uniformly convex, and almost circular. The front line is straight or slightly curved, surface smooth. Length 5, width 5½, depth 3 lines.

Glassia obovata is not an abundant species in Shropshire, but some good examples were obtained by Mr. Maw from the Buildwas Lower Wenlock shales.

5. *Glassia elongata*, n. sp. Pl. V. Figs. 3, 4.

Shell small, elongated oval, valves very gently convex, straight, or slightly rounded in front, tapering posteriorly, broadest anteriorly, beak small, incurved, surface smooth. In the interior of the dorsal valve the spirals are narrow anteriorly, but broader on the posterior side, and the principal coils on the posterior side of the spirals are, as in *Glassia obovata,* slightly notched or indented, the notch or indentation being in the direction of the end of the spiral, and occupying in most cases the whole breadth of the posterior border. The posterior border of the spirals, including, of course, the notch referred to, slopes slightly downwards on the ventral side towards the anterior margin, and arising from this the notch is partly seen in the ventral aspect of the spirals. This slope of the posterior border of the spirals also accounts for the upper part of the coils on the ventral side being more depressed and less oval than the corresponding part of the coils on the dorsal side.

I here append a restored outline sketch of the arrangement of the spiral coils in *Glassia obovata,* Fig. 18, from specimens developed by the Rev. N. Glass. The dorsal side of the coils in each spiral cone is somewhat displaced from its natural position in order to show the continuity of the coils. Fig. 19 shows that the coils are not circular, but elongated oval.



Spiral coils of *Glassia obovata.*
D dorsal, V ventral aspect.

6. *Meristella?* or *Atrypa? Mawei,* n. sp. Pl. V. Fig. 5.

Shell almost circular, as wide as long, valves moderately convex; ventral valve rather the deepest, no fold or sinus, but a slight longitudinal groove divides the dorsal valve into two equal lobes; beak not much produced, with a small circular foramen. Surface of valves marked at intervals by a few slightly projecting concentric ridges. Length 6, breadth 6, depth 3 lines.

Obs.—A single perfect specimen of this shell was found by Mr.

Maw among the debris from the old Wenlock limestone quarries at Benthall Edge in Shropshire. It is not possible to determine to what genus the shell should be referred, as its interior characters have not been ascertained, and it was not considered right to sacrifice the only specimen known in the attempt to discover the character of its spiral appendages. We have therefore provisionally put it with *Meristella.*

It is with much pleasure that I name this new species after its indefatigable discoverer, and in remembrance of the great labour and liberality with which he has assisted me in getting up the material for this communication.

7. *Streptis Grayii*, Dav. Pl. V. Fig. 13.

Atrypa ? Grayii, Dav., Sil. Mon. pl. xiii. figs. 14-22.

In 1846 I picked up two or three examples of this remarkable small twisted shell at Hayhead near Walsall, and described and figured it in 1848 in the Bulletin de la Soc. Geol. de France under the name of *Terebratula Grayii.* In 1859 Salter (in Siluria) made of it a *Rhynchonella.* Lindstrom in 1860 a *Spirigerina* ? and in my Silurian Monograph I provisionally put it with *Atrypa* ? adding, "my endeavours to procure specimens showing the internal character have proved fruitless, and I cannot determine exactly the genus." Knowing little or nothing of its interior arrangements, I felt extremely puzzled and uncertain as to the genus to which the shell should be referred, and, as justly remarked by Prof. James Hall at p. 38 of the 16th Annual Report on the State Cabinet of Natural History of New York, "so long as we remain unacquainted with the interior of the shell, we are compelled to refer the species to some genus having similar forms, though the fibrous or punctate structure may in many instances prove a valuable aid in these references." I have now seen upwards of one hundred and forty specimens of this remarkable species. and every individual presented exactly the same exterior character, and which I have described and represented at p. 141 and in pl. xiii. of my Silurian Monograph.

Possessing, thanks to Mr. Maw's great liberality, a number of good examples, I sent some of them to the Rev. Norman Glass to operate upon, and after many experiments on perfectly preserved specimens filled with spar and suitable to his operations he has informed me that he could in none of them detect the slightest trace of any calcareous support for the labial appendages—not the trace of a loop or spiral skeleton, and he was of opinion that it could not be referred to any of the genera into which it had been provisionally located. I therefore propose provisionally to place it under a distinct genus, and have selected the name *Streptis* (twisted), all the specimens hitherto discovered having presented that character. No calcareous support for the labial appendages, cardinal process much produced, hinge-teeth large and prominent.

8. *Rhynchonella cuneata*, Dal. and His. Pl. V. Fig. 10.

Sil. Mon. pl. xxi. figs. 7-11.

Since describing this well-known species at page 164 of my

Silurian Monograph, Prof. J. Hall has, at p. 166 of the Twenty-Eighth Annual Report of the New York State Museum of Natural History (1879), proposed a new genus, *Rhynchotretæ*, for the reception of Dalman's species, and which he characterizes in the following words:—

"Shell triangular, surface with angular plications, ventral beak straight, produced beyond the dorsal beak, extremity perforate, the foramen with an elevated margin; space between the foramen and the hinge-line occupied by a deltidium in two pieces, being divided by a longitudinal suture, and transversely striated. Valves articulated by two slender curving teeth, proceeding from a broad curving hinge-plate in the ventral valve, which fit into corresponding sockets in the dorsal valve. Cruræ rising from near the dorsal beak and curving into the ventral cavity, and thence recurved towards the dorsal side, and probably uniting, as shown in fig. 4 (Fig. 11 of our Plate). Structure fibrous and apparently very minutely punctate."

It seems quite evident that Prof. Hall has not actually seen the short Terebratula-shaped loop represented in his restored fig. No. 4 (Fig. 11 of our Plate), for he says in his description, "*and probably uniting, as shown in fig.* 4"—and in the explanations of his fig. 4 he adds, "the additional features of the loop represented in this figure have not as yet been satisfactorily determined." In order, if possible, to ascertain the internal character of this species, I asked the Rev. Norman Glass to develope the interior of several well-preserved specimens of *Rh. cuneata* from the Wenlock Limestone of Benthall Edge, and all of them showed only the two small curved lamellæ not attaining a third of the length of the dorsal valve, as in *Rhynchonella* proper. In no instance did Mr. Glass discover any indication of a loop. I would therefore leave Dalman's species with *Rhynchonella* until, on positive evidence, it can be shown to be generically separable.

9. *Rhynchonella Dayi*, sp. Pl. V. Fig. 9.

Obtusely deltoid or sub-pentagonal, wider than long, valves moderately convex, and divided into three almost equal lobes. Ventral valve not quite as deep as the dorsal one, divided by a broad well-defined mesial sinus, beak small, showing a small circular foramen margined by a deltidium, surface of valves ornamented with some fourteen or sixteen angular ribs, of which four form a well-defined mesial fold, the ribs being slightly bent upwards at the front, lateral margins of fold wide and flat. Length 5½, width 6, depth 3½ lines.

Obs.—This small species is well distinguished from young specimens of the same age of *Rh. borealis*, with which it had been confounded by its less triangular shape, as well as by the ribs of its fold being bent upwards close to their frontal extremity. In size and in number of ribs *Rh. Dayi* somewhat resembles small examples of the Jurassic *Rh. tetraedra.*

This small species was found by Mr. George Maw in the Wenlock Limestone of Benthall Edge, as well as in the Wenlock Shales underlying the limestone. I have much pleasure in naming it after the Rev. H. G. Day.

10. *Orthis elegantulina*, n. sp. Pl. V. Fig. 12.

Shell small, nearly circular, and about as broad as long. Dorsal valve moderately convex, divided longitudinally by a sinus of greater or lesser depth. Hinge area narrow. Ventral valve deeper, and more convex than the dorsal one, and slightly longitudinally keeled. Hinge-line shorter than the breadth of shell, beak small, incurved, area triangular, fissure small. Surface of both valves marked by strong raised striæ, bifurcating once or twice as they near the lateral and frontal portions of the valves. Length 3, width 3, depth 2 lines.

Obs.—My attention was first drawn to this small species at the commencement of 1880 by Mr. J. F. Walker. It is a much smaller shell than *Orthis elegantula*, and more circular, its beak much less incurved and of smaller proportions, and its ribbing or striation comparatively much stronger than in *O. elegantula.*

O. elegantulina swarms in the Lower Wenlock Shales of Buildwas in Shropshire, and is less abundant in the Upper Wenlock Shales.

11. *Eichwaldia Capewelli*, Dav. sp., Sil. Mon. p. 193, pl. xxv. figs. 12, 15.

Ever since I first described this beautifully sculptured shell in 1848, I have felt uncertain whether it was provided with spiral appendages. I consequently placed in the hands of Mr. Glass a number of well-preserved specimens filled with spar, and which had been obtained by Mr. Maw from his washing of Buildwas Lower Wenlock Shales. After many experiments not the trace of a spiral coil could be detected, and Mr. Glass arrived at the conclusion that it had none.

Prof. J. Hall having kindly sent me several well-preserved specimens of his *Eichwaldia reticulata*, I am convinced that it is the same species as my *E. Capewelli.* At page 170 of the Twenty-Eighth Report of the New York State Museum of Natural History, Prof. Hall says, " Surface of the shell, except a small place on the umbo of the ventral valve, covered by fine reticulate markings with elongate, generally hexagonal pits or openings, with thin and sharp ridges within; these markings vary in different specimens, and also in different parts of the same individual, being generally finest on the cardinal slopes. The small triangular space near the ventral beak which is destitute of marking has the appearance of having been exfoliated; but since this is an invariable character in all the individuals examined, varying in size with the size of the shell, it is probably dependent upon organic causes." This description of the shell sculpture, and of the *smooth part* at the *umbo* of the ventral valve, is exactly what we find, not only in our British specimens, but also in Swedish ones; and in pl. 2, fig. 16, of his " Fragmenta Silurica," Prof. Lindstrom gives a good illustration of this peculiarity.

12. *Streptorhynchus nasutum*, Lindstrom.

Cyrtia ? nasuta, Dav., Sil. Mon. p. 201, pl. xxv. figs. 1, 2.

For a long time much uncertainty has prevailed with respect to the genus to which this remarkable species should be referred. It was in 1860 described by Prof. Lindstrom as a *Strophomena*, but the fortunate discovery of perfect interiors of Swedish examples has enabled Prof. Lindstrom to place this shell in King's genus *Streptorhynchus*. Prof. Lindstrom's beautiful figures in pl. xvii. of his work "Fragmenta Silurica" clear up all uncertainty in the matter. This little shell appears still to be very rare in Great Britain, for I am acquainted with four specimens only. One of these was found by the Rev. H. G. Day in the Wenlock Limestone of Benthall Edge, another in the same limestone at Dudley, and the two specimens have been liberally presented to me by their discoverer.

13. Genus UNCITES, Defrance, 1828.

For many years past I have been on the look out for specimens that would clear up the interior characters of Defrance's Devonian genus. In 1853, in the General Introduction of my work on "British Fossil Brachiopoda," I described and figured part of the interior of the dorsal valve, showing the lateral pouch-shaped cavities opening exteriorly, as well as the attachments to the hinge-plate of the principal stems of the spiral appendages, also indications of the spiral appendages from a specimen which Prof. Beyrich of Berlin was so fortunate as to discover at Paffrath, and which was brought to my notice by Prof. E. Suess of Vienna.

In 1871, Prof. Quenstedt, in pl. 43 of the Atlas to his "Die Brachiopoden" (Petrefactenkunde Deutschland), figures spiral coils in a specimen of *Uncites*. No one, as far as I am aware of, seems to

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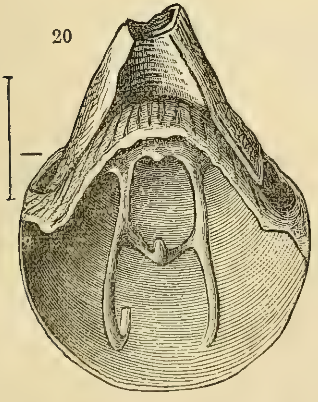

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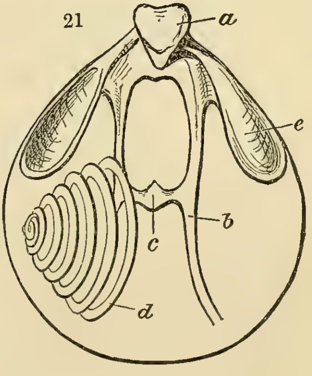

20. Specimens of *Uncites gryphus* in the Imperial Museum of Vienna.
21. Restored interior of the dorsal valve. *a* cardinal process; *b* principal stems of spirals; *c* connecting lamellæ; *d* spirals; *e* pouch-shaped expansions.

have described the mode in which the spirals were connected. After many inquiries in different directions, Prof. Zittel informed me that he believed there existed in the Imperial Museum of Vienna some specimens that might help in this investigation, and accordingly my old and valued friend Prof. Suess at once kindly obtained for my inspection the important specimen, Fig. 20, and in which are seen, not only the attachments of the principal stems of the spirals to the hinge-plate, but likewise their connection by the means of a curved bridge-like process, and which connects them at about half their length—small portions of the spirals themselves being also visible.

We are likewise indebted to Mr. A. Champernowne of Dartington Hall, Totness, not only for the discovery of the first British specimen of the genus, but also for finding a specimen showing the cardinal process, which in *Uncites gryphus* is heart-shaped and strongly developed. This valuable specimen was presented to the Albert Memorial Museum, Exeter, by its discoverer. I am now, therefore, for the first time able to offer a correct restoration of the interior of the dorsal valve (woodcut, Fig. 21).

Mr. Champernowne informs me that in addition to the locality, Orchard Quarry, Dartington, Mr. P. Vicary has obtained two specimens from the Chudleigh Limestone in Devonshire. We still remain unacquainted with the shape and position of the muscular impressions, but these will, in all probability, be some day discovered.

EXPLANATION OF PLATE V.

Fig. 1–2. *Glassia obovata*, Sow. sp.
,, 3–4. ——— *elongata*, Dav. The interiors of the valves or spirals are seen as a transparency.
,, 5. *Meristella ? Mawei*, Dav.
,, 6. *Waldheimia ? Glassei*, Dav.
,, 7–8. ——— *Mawei*, Dav.
,, 9. *Rhynchonella Dayi*, Dav.
,, 10–11. ——— *cuneata*, Dalman. 10 shows two short curved lamellæ only, as developed by Rev. N. Glass. 11 is taken from Prof. Hall's restored figure in p. 166 of 28th Annual Report of the New York Museum of Natural History.
,, 12. *Orthis elegantulina*, Dav.
,, 13. *Streptis Grayi*, Dav.

Note.—In the first part of this paper, published in the January Number, I stated that Mr. Whitfield "had been engaged in developing the spirals and their connections in the Palæozoic Brachiopoda, but only in American specimens, and principally in siliceous shells or in shells possessing a hard limestone matrix." I also stated that "Mr. Glass's operations had been confined almost entirely to English specimens, and to those English specimens only which were partly or wholly filled with spar." In my Carboniferous Supplement, published at the commencement of last year, I also stated that "some finely worked out specimens of American Palæozoic Spirifers, and other genera, have been described and illustrated by Prof. Hall and Mr. Whitfield; but in this case the results were obtained principally in siliceous specimens or by sections, and not developed in spar by the process Mr. Glass has discovered." I have recently received a note from Mr. Whitfield, in which he informs me that in the above statements I have been labouring under a mistake, that the siliceous specimens he has worked out are comparatively few, and that he has principally operated on specimens filled with calc-spar—these operations extending back for some years, and relating not only to American, but also to a number of European forms, including some from Bohemia and England. He says, "In fact I have treated my specimens exactly as Mr. Glass has treated his." Mr. Whitfield thus describes his method of operating—"I have been in the habit of cutting down to near the spires with tools, then treating with hydrochloric acid to render them more translucent, frequently cutting longitudinally a little outside of the middle so as to get the loop in profile. *Athyris vittata*, *A. spiriferoides*, *Meristina nitida*, and *M. Maria* are all cut thus." Mr. Whitfield also refers to a friend of his as having operated in a similar manner upon American specimens of *Atrypa reticularis,* and upon European specimens of *Tereb. scalprum.* Mr. John Young, of the Hunterian Museum, Glasgow, has also, in the course of correspondence, informed Mr. Glass that more than twelve years ago he operated upon four specimens—three of *Athyris ambigua*, and one of *A. Roysii*—developing the spirals from their sparry matrix by means of acid and a file and knife. More recently, as I stated in my Carboniferous Supplement, Mr. James Neilson, Jun., has developed in the same manner the spirals in *A. Roysii* and *Sp. lineata.*

As to the English forms worked out by Mr. Whitfield, I may state that I have never seen any drawings of them—my knowledge of the spirals and their connections in those of our English Brachiopods which are filled with spar having been entirely derived from the preparations of Mr. Glass. Mr. Glass, as he informs me, does not lay any claim to the discovery that the Palæozoic spiral-bearing forms of the Brachiopoda which are filled with spar are favourable to the development of the spirals and their connections, nor does he lay any claim to the first employment for such a purpose of the knife supplemented by acid—though he was the first to publish any account of such a process, and it was only after he had done this that he became aware of its previous use. He thinks, however, that his own method is somewhat different to that previously employed. In the comparatively simple matter of developing the spirals Mr. Glass has found through operating upon many hundreds of specimens that to obtain the best and most finished results the acid should first be used in removing the outer valve or valves when they have not been transformed into spar. That then scraping with a knife and frequent washing with water must be solely relied upon until the spirals are clearly revealed without even a trace of the sparry matrix upon them. Then to obtain a perfectly smooth surface, fine emery cloth must be used, and finally the specimen must be dipped for two or three seconds in the acid to remove the dullness of the surface and to give to it a glossy and transparent appearance as if it had been polished. As to the more difficult matter of developing the connections of the spirals, Mr. Glass has found that the only method giving any certainty of result is by limiting the use of the acid as described above and by scraping away the matrix and parts of the spirals until the connections of the spirals with the hinge-plate, and the connection of the spirals with each other are completely exposed.

Mr. Glass says that in his own operations he places no dependence upon the making of sections, though he has no doubt that those who have a preference for this mode may sometimes use it with good effect.

Since writing the above Mr. Whitfield has kindly forwarded to me a specimen of *Meristella arcuata* in which the spirals and their connections are silicified. Mr. Whitfield only partly prepared this specimen, so that the very delicate and fragile loop might be preserved during transit, and said in his accompanying note—"It will need careful working with acid in order to develop it so as to shew the loop rings and processes." Having sent the specimen to Mr. Glass he has successfully worked it out, and the rings of the loop appear very plainly as previously figured by Prof. Hall. Now as in *Meristella tumida* there are no rings it cannot properly belong to the genus *Meristella*. Mr. Whitfield agrees with me in thinking that it is identical with the American *Meristina Maria*. Certainly *Meristina Maria* agrees very closely with our *Meristella tumida* in external form, and Mr. Glass has just worked out a typical specimen of the American species sent to me by Prof. Hall which proves beyond doubt that the connections of the spirals with the hinge-plate and their connection with each other are identical in both species. In the American description of the interior of *Meristina Maria* the loop is said to be simple, but it is now proved that the end of the loop is bifurcated in exact agreement with the figure of the interior of *Meristella tumida* given in the first part of this paper.

Mr. Glass has worked out a specimen of *Meristella didyma*, which is probably identical with the American *Meristina nitida*. In this specimen Mr. Glass thinks he has developed a simple loop such as that described by Prof. Hall for his genus *Meristina*. I am not quite sure of this, however, and think it desirable that we should have further evidence, but if Mr. Glass's supposition should prove correct, then the genus *Meristina* should be retained for this and similarly organized species, and *Meristella tumida*, with its synonym *Meristina Maria*, should constitute a new genus which I would name *Whitfieldia*.

II.—SKETCH OF THE GEOLOGY OF BRITISH COLUMBIA.

By George M. Dawson, D.S., A.R.S.M., F.G.S.

TWENTY years ago the region now included in the Province of British Columbia was—with the exception of the coast-line—little known geographically, and quite unknown geologically. From the days of Cook and Vancouver, and the old territorial disputes with the Spaniards, this part of the west coast of North America attracted little attention till the discovery of gold in 1858. As among the first in the field geologically may be mentioned Dr. Hector and Messrs. H. Bauerman and G. Gibbs. The observations of these gentlemen, though bringing to light many facts of interest, were confined to a comparatively small part of the area of the province, and it was not till the inclusion of British Columbia in the Dominion of Canada in 1871 that the systematic operations of the Geological Survey of Canada were extended to this region. Since this date a number of reports treating of the geology of British Columbia have been published, and on these, together with a personal knowledge of the country, obtained during five seasons' work in it in connexion with the Survey, I shall chiefly depend in giving a brief account of the main geological features so far developed.

British Columbia includes the whole breadth of a portion of the great Cordillera belt which forms the Pacific margin of the Continent. This here consists of four parallel mountain ranges running in general north-westerly and south-easterly bearings, which, beginning on the Pacific Margin, may be named as follows:—Vancouver Range, Coast or Cascade Range, Gold Range, and Rocky Mountain Range proper, the last constituting the western border of the great plains of the interior of the Continent.

The first mentioned, in a partially submerged condition, forms Vancouver and the Queen Charlotte Islands, and still rears some of its peaks to a height surpassing 6000 feet. The valley lying to the north-east of this is occupied by the sea, forming the Strait of Georgia, Queen Charlotte Sound, and Hecate Straits. The Coast Range is a rugged mountainous district with a width of about one hundred miles, and axial summits reaching in some places elevations surpassing 8000 feet. To the north-east of this stretches a region which may be called the Interior Plateau of British Columbia, the average width of which is nearly one hundred miles, and its mean elevation about 3500 feet. This plateau is, however, irregular, hilly, or even in some places mountainous, and is intersected by deep trough-like river valleys. It is only when it is occupied by Tertiary volcanic rocks that it assumes considerable uniformity of surface.

Bounding the plateau to the north-east is a third wide range, known locally as the Cariboo, Columbia and Purcell Mountains. It is broken to the north at the 54th parallel and resumes under the 56th as the Omineca Mountains. This mountain axis may be named the Gold Range, and it is probable that many summits in it surpass 8000 feet. Separated from it by a narrow but well-defined valley is the Rocky Mountain Range with an average width of fifty to sixty miles. This shows peaks of about 10,000 feet in height on the 49th parallel, is supposed to surpass 15,000 feet near the 52nd, and becomes comparatively low and narrow in the vicinity of the Peace River, about the 56th parallel.

Such are the main orographical features of British Columbia, a slight knowledge of which is necessary to render intelligible the description of its geological structure.

In describing the rocks, those of Tertiary and Cretaceous age of the coast will first be noticed, next those of the interior of the province referable to these periods, and lastly the older underlying metamorphic rocks.

Tertiary.—The Tertiary rocks do not form any wide or continuous belt on this part of the coast, as is the case farther south. They are found near Sooke, at the southern extremity of Vancouver's Island, in the form of sandstones, conglomerates, and shales, which are sometimes carbonaceous.[1] Tertiary rocks also probably occupy a considerable area about the mouth of the Fraser River; extending southward from Burrard Inlet, across the International boundary formed by the 49th parallel, to Bellingham Bay and beyond. Thin seams of lignite occur at Burrard Inlet. Sections of the Tertiary rocks at Bellingham Bay are given in Dr. Hector's official report. Lignite beds were here some years ago extensively worked, but the mine has been abandoned owing to the superior quality of the fuels now obtained from Nanaimo and Seattle. About the estuary of the Fraser the Tertiary beds are much covered by drift and alluvial deposits, and are consequently not well known. Lignites, and even true coals, have been found in connexion with them, but so far in beds too thin to be of value. Fossil plants from Burrard Inlet and Bellingham Bay have been described by Newberry and Lesquereux, and these are supposed to indicate a Miocene age for the deposits.[2]

Much farther north, in the Queen Charlotte Island, the whole north-eastern portion of Graham Island has now been shown to be underlain by Tertiary rocks, which produce a flat or gently undulating country, markedly different from that found on most parts of the coast. The prominent rocks are of volcanic origin, including basalts, dolerites, trachytic rocks, and in one locality obsidian. Numerous examples of fragmental volcanic rocks are also found. Below these, but seen in a few places only, are ordinary sedimentary deposits, consisting of sandstones or shales, and hard clays with lignites. At a single locality on the north end of Graham Island, beds with numerous marine fossils occur. These, in so far as they admit of specific determination, represent shells found in the later Tertiary deposits of California, and some of which are still living on the north-west coast; and the assemblage is not such as to indicate any marked difference of climate from that now obtaining.[3]

The Tertiary rocks of the coast are not anywhere much disturbed or altered. The relative level of sea and land must have been nearly as at present when they were formed, and it is probable that they originally spread much more widely, the preservation of such an area as that of Graham Island being due to the protective capping

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[1] Report of Progress, Geol. Survey of Canada, 1876-77, p. 190.

[2] In the geology of the U. S. exploring expedition, Prof. Dana describes some Tertiary plants from Birch Bay. These were afterwards reported on by Newberry, Boston Journ. of Nat. Hist. vol. vii. No. 4. See also American Journal of Sc. and Arts, 2nd series, vol. xxvii. p. 359, and vol. xxviii. p. 85. Report on the Yellowstone and Niusain expedition, 1869, p. 166. Annals Lyc. of Nat. Hist. of N. Y., vol. ix. April, 1868.

[3] Report of Progress, Geol. Survey of Canada, 1878-9, p. 84 B.

of volcanic rocks. The beds belong evidently to the more recent Tertiary, and though the palæontological evidence is scanty, it appears probable from this, and by comparison with other parts of the west coast, that they should be called Miocene.

To the east of the Coast or Cascade Range, Tertiary rocks are very extensively developed. They have not, however, yielded any marine fossils, and appear to have been formed in an extensive lake, or series of lakes, which may at one time have submerged nearly the entire area of the region described as the interior plateau. The Tertiary lake or lakes may not improbably have been produced by the interruption of the drainage of the region by a renewed elevation of the coast mountains proceeding in advance of the power of the rivers of the period to lower their beds; the movement culminating in a profound disturbance leading to very extensive volcanic action. The lower beds are sandstones, clays, and shales, generally pale-greyish or yellowish in colour, except where darkened by carbonaceous matter. They frequently hold lignite, coal, and in some even true bituminous coal occurs. These sedimentary beds rest generally on a very irregular surface, and consequently vary much in thickness and character in different parts of the extensive region over which they occur. The lignites appear in some places to rest on true "underclays," representing the soil on which the vegetation producing them has grown, while in others—as at Quesnel—they seem to be composed of drift-wood, and show much clay and sand interlaminated with the coaly matter.

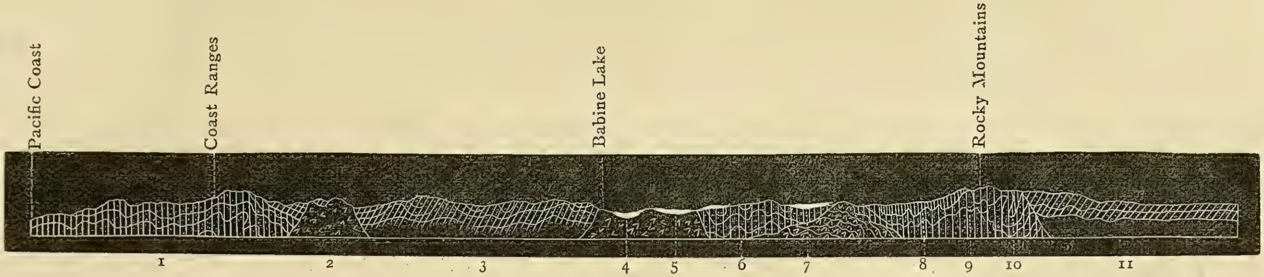
In the northern portion of the interior the upper volcanic part of the Tertiary covers great areas, and is usually in beds nearly horizontal, or at least not extensively or sharply folded. Basalts, dolerites, and allied rocks of modern aspects occur in sheets, broken only here and there by valleys of denudation; and acidic rocks are seldom met with except in the immediate vicinity of the ancient volcanic vents. On the Lower Nechacco, and on the Parsnip River, the lower sedimentary rocks appear to be somewhat extensively developed without the overlying volcanic materials.

The southern part of the interior plateau is more irregular and mountainous. The Tertiary rocks here cover less extensive areas, and are much more disturbed, and sometimes over wide districts—as on the Nicola—are found dipping at an average angle of about thirty degrees. The volcanic materials are occasionally of great thickness, and the little disturbed basalts of the north are, for the most part, replaced by agglomerates and tufas, with trachytes, porphyrites, and other felspathic rocks. It may indeed be questioned whether the character of these rocks does not indicate that they are of earlier date than those to the north, but, as no direct palæontological evidence of this has been obtained, it is presumed that their different composition and appearance is due to unlike conditions of deposition and greater subsequent disturbance.

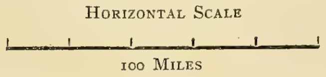
No volcanic rocks or lava flows of Post-glacial age have been met with, though I believe that still farther to the north-west the rocks are of yet more recent origin than any of these here described, and

GEOLOGICAL SKETCH MAP OF BRITISH COLUMBIA.

SKETCH SECTION ACROSS THE CORDILLERA REGION IN THE VICINITY OF THE 55TH PARALLEL.



1. Gneiss mica- and hornblende-Schists of the Coast Ranges.
2. Granite.
3. Cretaceous Sandstones, Shales and Slates, with impure Coals.
4. Granite.
5. Outliers of Tertiary volcanic rocks.
6. Limestone, Schists and Quartzites Palæozoic, in part Carboniferous.
7. Highly Crystalline Gneiss and mica Schist Archæan (?).
8. Schists and Slates Triassic (?).
9. Limestones, Schists and Quartzites Palæozoic.
10. Triassic Monotis shales.
11. Cretaceous rocks of the Peace River Country.



I have even heard a tradition of the Indians of the Rasse River which relates that, at some time very remote in their history, an eruption covering a wide tract of country with lava was witnessed.

The organic remains so far obtained from these Tertiary rocks of the interior consist of plants, insects, and a few freshwater molluscs and fish scales, the last being the only indication of the vertebrate fauna of the period. The plants have been collected at a number of localities. They have been subjected to a preliminary examination by Principal Dawson, and several lists of species published. While they are certainly Tertiary, and represent a temperate flora like that elsewhere attributed to the Miocene, they do not afford a very definite criterion of age, being derived from places which must have differed much in their physical surroundings at the time of the deposition of the beds. Insect remains have been obtained in four localities. They have been examined by Mr. S. H. Scudder, who has contributed three papers on them to the Geological Reports,[1] in which he describes forty species, all of which are considered new. None of the insects have been found to occur in more than a single locality, which causes Mr. Scudder to observe that the deposits from which they came may either differ considerably in age, or, with the fact that duplicates have seldom been found even in the same locality, evidence the existence of different surroundings, and an exceedingly rich insect fauna.

Though the interior plateau may at one time have been pretty uniformly covered with Tertiary rocks, it is evident that some regions have never been overspread by them, while, owing to denudation, they have since been almost altogether removed from other districts, and the modern river valleys often cut completely through them to the older rocks. The outlines of the Tertiary areas are therefore now irregular and complicated.[2]

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

III.—ON A CASE IN WHICH VARIOUS MASSIVE CRYSTALLINE ROCKS INCLUDING SODA-GRANITE, QUARTZ-DIORITE, NORITE, HORNBLENDITE, PYROXENITE, AND DIFFERENT CHRYSOLITIC ROCKS, WERE MADE THROUGH METAMORPHIC AGENCIES IN ONE METAMORPHIC PROCESS.

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Part III.

(Concluded from page 119.)

THE extent of these bands, their number, uniformity of direction and apparently of dip, and the identity of the material constituting them with beds of the schist, especially the more northern, are such as to warrant the following section (Fig. 15).

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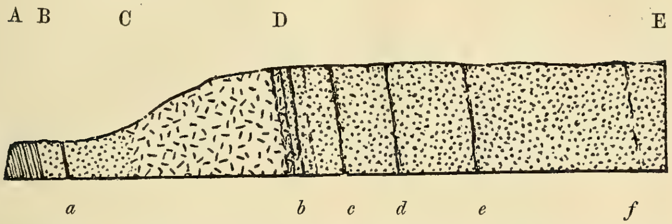
[1] Reports of Progress, Geol. Survey of Canada, 1875–6, p. 266; 1876–7, p. 457; 1877–8, p. 175, B.

[2] For additional information on the Tertiary rocks of the interior, see the following Reports of Progress, 1871–2, p. 56; 1875–6, pp. 70 and 225; 1876–7, pp. 75 and 112, B.

A B represents a portion of the schist near the granite; B to C, soda-granite; C to D, coarse syenite-like diorite; D to E, soda-granite; *a* to *f*, the bands, which are lettered as in the above descriptions of them.

FIG. 15.



The depth to which the beds are made to descend downward in the granite (100 feet) is an assumption in this section; but considering that probably 5000 feet, and more likely over 10,000 feet of these upturned rocks have been removed by erosion, and noting also the number of the bands and their parallelism to the schist, and the effect of pressure to keep them in place, the assumption can be no exaggeration.

Since it is obviously impossible that the inclusions taken in and carried up by rocks erupted through deep fissures should be beds of schist 100 to 200 feet long, and a series of such beds separated by the fused rock retaining together their parallel position, we have to admit that these indications of bedding are of *unobliterated* bedding. The rest of the upturned strata were fused or at least softened; these portions of beds were not fused, though flexed and variously displaced.

There is reason for the resistance to fusion in the mineral nature of the beds; for quartz, staurolite, fibrolite, magnetite, are infusible minerals; muscovite and biotite are but slightly fusible on thin edges; and orthoclase fuses with great difficulty, much greater than the other felspars, oligoclase, labradorite and albite.

Thus the study of the phenomena of contact becomes in this region a study of "inclusions"; and the larger of the inclusions turn out to be beds of schist, conformable to the schist.

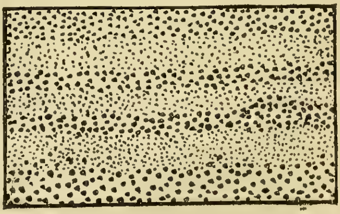
We seem to be thus forced to the conclusion that the soda-granite and the included diorite were once parts of the same sedimentary strata with the schist, and that all, with the Cruger limestone, were once a continuous stratified formation; and that the plasticity given to the granite-making or diorite-making portions, because of the heat, occasioned the exceptional geological features of the region.

The region of Cruger's Point is continued northward into that of Montrose Point; the latter is characterized, as has been stated, by chrysolitic rocks for its southern three-fourths, and by norite with chrysolitic rock for the other fourth; and through the facts there as well as elsewhere afforded, the evidence from inclusions is made to extend also to these other rocks. With the chrysolitic pyroxenite and chrysolitic hornblendite, there is also hornblendite which is not chrysolitic, but more or less augitic, and containing some triclinic felspar. On the south side of Montrose Point facing Cruger's Point (or the brick-yard between the two), in the chrysolitic rock, there is what looks like a vein or dyke two to four inches wide, exposed for a length of twenty feet. The material shows it to be no vein or dyke, but a bed from the schist; it is a dark-coloured quartzose *garnet rock,* heavy with magnetite and containing some staurolite, resembling much a portion of the schist in section 1 (above described), near the soda-granite. The covering of earth prevented a determination of its whole extent. In the same kind of rock, about fifty yards north of the brick-yard which divides Montrose Point (into a North Montrose and a South Montrose Point), a vein-like band, two feet to twenty inches wide, descends the bluff, which consists of a light-grey massive argillite. Examined in thin slices by the microscope, it is found to have a mealy aspect with microlithic points, like an argillite in the first stages of metamorphism. The band is a bed from the schist, although a different variety of it from any exposed at Cruger's.

Other long vein-like bands are black and of very fine grain; some of them look greyish and minutely arenaceous. The microscope shows, on an examination of thin slices, that some consist of grains of hornblende and felspar, the latter partly orthoclase, and look like hornblende schist, while others are very fine-grained hornblendic mica-schist. One of the latter had a thickness of two feet. These bands are most numerous in the norite of the northern part of the point. Figure 4, as stated on page 111, represents an "inclusion" in the norite; but the inclusion is evidently a *bed bent back on itself*; for a vein would not be thus folded double in its enclosing rock. The rock of this *bed* much resembles the norite, though finer in grain, and consists (as observed by means of a thin slice) of hornblende with much augite and some triclinic felspar.

On the same part of the point, the norite and chrysolitic rocks apparently cut through one another, but with the norite oftener like an inclusion in the chrysolitic rocks. Again, they follow one another, or lie side by side, but without a distinct divisional plane; and in one place the rock consists of bands of norite and chrysolitic hornblendite without a trace of any planes of separation. Figure 16 represents an example of this kind, in which the bands are two to three inches wide, norite bands (the fine-dotted in the figure) alternating with bands of the chrysolitic rock. Difference of material in successive portions might, under some metamorphic conditions, give rise to such a structure, although the bands are so thin; successive outflowing of different eruptive rocks could not produce it.

Fig. 16.



Going north from the vicinity of Cruger's Station along section 1, instead of section 3, the rocks change from the coarse diorite at the end of the section to fine-grained; and then, in three-fourths of a mile, the rock is well-characterized norite. Moreover, the norite contains a band of magnetite, exposed in a working (near Mrs. Murden's) with which occur garnet and fibrolite. The band is bedded, the magnetite is chloritic, and the assemblage of minerals is the same that occurs in the soda-granite, as well as the schist west of Cruger's. Fibrolite is found also with the magnetite of Eastern Cortland.

The norite and chrysolitic rocks are thus apparently in the same category with the soda-granite and quartz-diorite.

Stony Point.—This conclusion is further sustained by the facts to be observed at Stony Point, and these facts come into this place, although the locality is on the west side of the Hudson; for the Cruger schists make the south border of the region precisely as near Cruger's, and have the same strike and dip, showing a like relation to the Cruger limestone belt and proving its former extension across the river. For further comparison between the geological facts of the east and west sides of the river, it is to be observed that the succession of rocks west of Cruger's, on the line going northward, from the river on the south side of the point to the north side of Montrose Point, is (1) limestone; (2) schist; (3) soda-granite (with some included diorite); (4) chrysolite rocks; (5) (on Northern Montrose Point) norite and chrysolitic rocks in complicated combination.

The same is the order on Stony Point, except that the limestone is not in sight (no doubt because submerged); it is: (2) schists; (3) soda-granite; (4) chrysolite rocks, followed by (5) norite and chrysolite rocks combined. (The diorite of the Cruger soda-granite is not represented there.) On the map, x is the area of the schists; y, the soda-granite; z, the chrysolitic rocks, and z' the latter with norite. But besides being the same in order, there is evidence that the soda-granite succeeds the schist *along a plane of bedding* of the schists, as if conformable. This is apparent at the junction of the two on the east-north-east shore of the point. Included beds of schist occur, but the covering of earth prevents a determination of their direction. Further, the chrysolitic rocks succeed to the soda-granite along a plane parallel to the same plane of bedding, as is seen just west of the boat-pier near the middle of the northern shore. Besides these facts, there are included beds of fine-grained hornblende rock (schist ?) and other kinds in the norite and chrysolitic rocks, which are in general conformable to the same plane, or about N. 70° E. in strike, with a dip of 75° to 80° to the northward.

Such facts sustain the inference as to the former connexion of the rocks of the east and west sides of the river, and strongly favour the view that the succession in the rocks noted was dependent originally on stratification.

If the thickness of the schists at Cruger's Point may be taken as that at Stony Point, the submerged Cruger limestone is to be found beneath the bottom mud of the river within a few hundred feet of the south-east shore.

(2) *Vicinity of the Peekskill Limestone areas.*—The Peekskill limestone areas have similar stratigraphical relations to the norite and the other Cortland rocks. One of the two areas extends up Sprout Brook or Canopus Hollow, and the other up the valley in the village of Peekskill along which Center-street descends toward the river. The southern extremities of these areas are shown on the map, page 60; the former has the strike N. 52° E. and dip 75° S.; the latter N. 78° E. dip 75° S. Figure 17 represents a section about 1300 yards in length from north to south, along the line marked *a b c* on the map, starting from the limestone at the mouth of Sprout Brook, near the Ironworks. The limestone (*a*) lies against true, whitish, well-bedded, conformable quartzite (*a* to *b*); this quartzite changes gradually to jointed massive granitoid and gneissoid quartzite, with only an occasional bedded band or plane; each such band or plane is conformable in direction to the limestone and the adjoining bedded quartzite. This quartzite (the rock referred to on p. 24, vol. xx. Am. Jour. Sci.) continues southward to the Center-street valley, but on the north side of the valley, just back of Hill's Foundry, it is followed by an arenaceous mica-schist (*c d*), with the strike varied to N. 78° E. the dip remaining the same; then, on the south side of the valley, 50 yards above Baxter's Iron Works (on Water-street), the limestone of the *second* belt outcrops, having the same dip and strike as the mica-schist; and behind these ironworks, thin-fissile dark-grey mica-schist (containing both white and black mica) appears conformable in position to the limestone; then, after an earth-covered interval of about 200 yards, there is an outcrop of massive norite along South-street, north of Hudson-street, which is without bedding, but has an extremely micaceous layer—a kind of coarse mica-schist—intersecting it near its middle, which is *conformable in its strike and dip with the mica-schist and limestone of Center-street valley;* and it shows conformable planes of bedding also near its south extremity. Moreover, this norite has a lighter-grey colour and contains more quartz and orthoclase than in other outcrops more remote from the mica-schist and limestone, and thus exhibits an intermediate character corresponding with its intermediate position. This stratification in portions of the norite is also distinct a mile to the eastward of this locality on the same side of the limestone, at the point mentioned on page 59.

Fig. 17.

The granitoid and gneissoid quartzite of Peekskill *looks* much like true granite and gneiss; but its transition to bedded quartzite shows what it in fact is; and this is confirmed by the examination of thin slices, the quartz in it proving to consist of an aggregation of grains just like a sandstone. (The transition of this granitoid quartzite to schist or slate has been mentioned on page 24, vol. xx. Am. Jour. Sci.) These facts are all in favour of the conclusion that the norite was once a stratum conformable to the Peekskill limestone areas.

(3) *Vicinity of the Verplanck Limestone belt.* — The Verplanck limestone belt follows the border of the river from a point just north of the foot of Broadway, and has the usual strike for the county, north-eastward. Like the Cruger limestone area, it has, on the landward side, with a small exception, a border of ordinary mica-schist or micaceous gneiss, a fine-grained arenaceous rock, the felspar of which is mostly orthoclase. This schist extends to the point marked *d* on the map: at *c* the rock is massive norite, but no junction of these two rocks is here in sight.

The exception referred to is at the south-west extremity of the belt on the river. Here there lies against the eastern side of the limestone a great mass of greyish or brownish-black rock of the Cortland series. It is mostly pyroxenite, moderately coarse in grain, but varies to a kind in which the augite individuals are half an inch broad, and, on the other hand, to a fine-grained variety; and it contains, besides augite, a little hornblende, quartz, calcite, and apatite. But portions of the mass consist of coarsish hornblendite; and a small part of micaceous augite-norite; and there are also broad and narrow bands of very fine-grained black hornblendic mica-schist, not showing well a schistose structure, part of which are conformable in strike and dip with the beds of the limestone, while others are in other positions. All the material is very pyrrhotitic. Besides, it contains the remarkable limestone breccia, of which a portion three feet square is represented on p. 111.

This singularly-constituted mass shows no appearance that looks like a subdivision into dykes or veins, except in the bands of hornblendic mica-schist; one of these bands has a border of the micaceous augite-norite just mentioned. In the limestone just north of this mass, facing the river, occur the supposed dykes or veins mentioned on page 111. Some of them consist of pyroxenite; others of coarsish hornblendite; very fine-grained hornblendic rock looking like hornblende schist (*Ae*); very fine-grained hornblendic mica-schist; augite-norite.

As already admitted, there is here abundant evidence of a former plastic state in at least part of this augitic and hornblendic material. Still, there are strong reasons for questioning the idea of its deep-seated origin. 1. The variety in the constitution of the mass bordering the limestone and in the supposed dykes or veins is very unlike what is ordinarily found in regions of igneous eruption. 2. The supposed veins or dykes are for the most part conformable with the bedding of the limestone, and partake in its flexures, just as if they had been originally beds alternating with the limestone depositions. 3. The impregnation of the limestone along the junctions with pyroxenic or hornblendic material, sometimes minute crystals, looks as if it may have been in part at least a result of mixture attending original deposition.

Further (4), there is the decisive fact that these intercalated masses are represented to the northward by bands ten feet and less to over thirty feet in thickness, of a black fine-grained mica-schist, very pyritiferous. Going from the Point, the first outcrops of interstratified schist and limestone occur after an earthy interval of 300 yards, and here the mica-schist is *hornblendic*, a feature it loses to the northward. These beds of mica-schist have just the positions of most of the supposed "veins," and appear to be their more northern portions; and further, among the more northern "veins" of the Verplanck shore, some are *simply mica-schist.* Such facts explain also many of the vein-like bands of Montrose and Stony Points. The difference in mineral constitution between such interstratified beds to the northward and on the shore is what should be expected; for the limestone is bordered to the eastward in the one case by true mica-schist, and, in the other, by augitic or hornblendic beds; and the associations at Montrose and Stony Points are similar. This view is also sustained by the occurrence in the limestone near the schist, 1000 yards from the Point, of coarse spots of pyroxene with mica and chlorite, rudely in layers, which must be due to the original deposition of impurity and metamorphic action. The augitic rock (pyroxenite) on the east of the limestone at the Point outcrops (owing to excavations in the drift) for 200 yards from the shore; but its place beyond this continues covered for three-fourths of a mile, and here the rock is arenaceous mica-schist; the spots of pyroxene are its only representative.

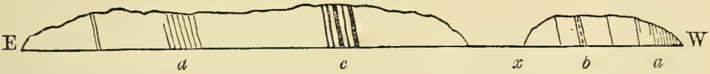
The essential continuity of these intercalated beds of mica-schist with the intercalated beds of augitic and hornblendic material along the coast proves identity of origin, and origin by sedimentation. It indicates also a small change of constitution in the beds as they extend in that direction. The plasticity occasioned in part of the latter, during the progress of the metamorphism, accounts for all that looks like eruptive phenomena, even to the broken felspar grains found in a slice of the pyroxenite of one of the so-called veins. There is nowhere evidence of injection into or through cold rocks.

(4) *Vicinity of the smaller limestone areas of the Verplanck Peninsula.*—Six small limestone areas occur in the Verplanck peninsula. They are lettered on the map 1 to 5 and *j*. Number 3 has the strike of the large Verplanck belt, and has about it the same arenaceous mica-schist. The others are in the midst of, or adjoin, the norite, diorite, and chrysolitic rocks, and hence might be put down among the "inclusions" of the region. In addition, they have a *north-west* strike (N. 17°—40° W.). But this is the strike, in part of Cruger's limestone area, and in a portion of the Verplanck belt, so that the twist is not confined to them. And, among so extensive masses of rock that became plastic or fused in the era of upturning, this abnormal position of included strata is not strange. Numbers 2 and 5 are probably parts of the belt; and numbers 1 and 4 may be in the same line, though disconnected by intervening rocks. The following are some of the stratigraphical facts observed among them.

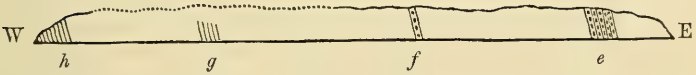
No. 4, at Centerville, has at middle on its east side the compact porphyritic mica rock, *Cb*, which is schistose directly adjoining the limestone in the field west of the road, and has the strike of the limestone N. 47° W. But to the westward in the field (in which the limestone can be traced for 250 yards with a change of strike to N. 62° W.) the mica rock changes to hornblendite and quartz-diorite; and to the south-eastward along the road, augite-norite appears within a few feet of the limestone, both the felspathic fine-grained (almost cryptocrystalline) variety (*Bc*), and the coarser dark variety. Whether this latter change in the bordering rock is due to a fault or not, could not be ascertained; it was not due to an intrusive dyke.

No. 5 outcrops on the railroad at 5 (see map) and on two roads at 5′ and 5″, with the strike N. 32° W. Between Montrose Station and this limestone at 5″, the rock is norite, excepting some greyish augitic rock (*Bc*) at the corner (Munger's), where the road turns west, and an outcrop of *chrysolitic* norite (hypersthene rock) 135 yards west of Munger's. Eighty yards beyond the chrysolitic rock comes the outcrop of limestone. One hundred and fifty yards west of the small exposure of limestone on the north side of the road, a ledge commences which extends along for nearly 350 feet, with no dyke-like subdivisions. It *consists mainly of norite, but with some hornblendite and norite-gneiss, and has distinct planes of bedding in several places, all of which are conformable to one another.* The strike of its beds is N. 27° W., or nearly that of the limestone, and the dip 60° to 70° E. Part of the norite is garnetiferous. Figures 18, 19 represent the stratification observed in the ledge—Fig. 18 the eastern portion, and 19 the western; forty feet of earthy interval separates the two. At the east end, at *a*, the rock (as a slice shows) is hornblendite (with about equal proportions of orthoclase and triclinic felspar), and it is schistose. It passes at the place to coarsish quartz-diorite. At *b*, it is well-defined micaceous gneiss or norite-gneiss, affording perfect observations of the strike and dip. West of this the rock is mainly norite and augite-norite. At *c*, for eight feet, black bands (or beds less felspathic than the rest) alternate with the ordinary grey-black rock, and exemplify the conformability stated, though without divisional planes; at *d*, are divisional planes in the grey-black augite-norite, having the strike N. 27° W. and dip 70° E. At *e*, is a much decomposed micaceous gneissic layer (norite-gneiss apparently) conformable in strike, but varying in dip from 40° E. to 60° E.; at *f*, a distinct bed of light-coloured very felspathic augite-norite, deeply decomposed, having the conformability; at *g*, or the west end, the rock is again mica-

18.



19.



ceous and gneissic, with some garnets, the bedding distinct, and N. 27° W. in strike as at the east end.

This ledge, although made up mainly of massive norite and augite-norite, bears thus positive evidence of its having once had bedding throughout, and affords thereby a demonstration that its norite is of metamorphic origin, and that the associated beds comprised also the limestone of the region.

(5) *A bed of quartzite in norite.*—About half a mile east of the limestone number 5, about the Montrose Station, the rock is the ordinary dark-coloured norite. 120 yards up the road going north-eastward from the station, a bed of *whitish granitoid quartzite* outcrops on the roadside for seventy yards, first on the west and then on the east side. This bed of quartzite *overlies norite.* The norite near the quartzite is micaceous, quartzose and schistose, and that underneath is of the ordinary massive kind. There is evidence also that the bed of quartzite has norite above as well as below it. The quartzite looks somewhat like a pale quartzose porphyritic granite; but, as observed in thin slices, the quartz consists of aggregated grains like sandstone; showing a resemblance to the Peekskill quartzite. The felspar is mainly orthoclase.

C. Conclusions as to the Cortland Rocks.

Many more observed facts might be here reported. But the above appear to be sufficient to settle the question as to the relations of the rocks of the Cortland series. They appear to sustain fully the following conclusions:—

(1) These rocks, although they include soda-granite, norite, augite-norite, diorite, hornblendite, pyroxenite, and chrysolitic kinds, are not independent igneous rocks erupted from great depths.

(2) However complete their former state of fusion or plasticity may have in some cases been, they are metamorphic in origin.

(3) The strata that underwent the metamorphism were one in series and conformability with the adjoining schists and limestone, and were part of the Westchester limestone series. (They are *younger* rocks if of different age, since they contain and intersect portions of the Verplanck limestone.)

(4) These Cortland rocks differ from the other Westchester County rocks because the metamorphic process had to do with sedimentary beds that differed in constitution or were in some respects under different conditions from those that existed elsewhere.

On the view reached, it follows that the limestones, schists, and other rocks of the Cortland region originally constituted together one series of horizontal strata. They underwent an upturning through subterranean movements, and in the course of it, they became metamorphosed; part into mica-schist and gneiss, part by loss of bedding, into the massive rocks. The number of these rocks does not imply widely different ingredients in the original strata. For hornblendite and pyroxenite have the same chemical constitution; the chrysolitic rocks contain no ingredient not in them also, and are peculiar mainly in their less proportion of silica. Moreover, the diorite, norite, and augite-norite are alike in containing the same bases in nearly the same proportions. The soda-granite differs in chemical constituents only through its mica, which indicates the presence of potash; but the other rocks also are often micaceous and contain in addition more or less orthoclase. Silica, alumina, iron protoxide, magnesia, lime, soda, potash, are all the essential ingredients obtained in analyses of these various rocks (excluding the magnetite, apatite, pyrrhotite, and pyrite); and it is not mysterious, therefore, that such rocks should be among the results of metamorphism.

The geologist will nowhere on the continent find a more instructive spot for a day's walk than in the western portion of the Cortland region. Starting from Cruger's Station (37 miles from New York City), a walk of half a mile brings him to the western brick-yard shed; going north from here by a wood road carries him along section 3, and in less than a mile in a northerly direction (passing brick-yards at the end of it) he will reach Montrose Point and the chrysolitic rocks; following these around by the shore for about a mile he will then pass a brick-yard on the Point, and beyond it find the norites and chrysolite rocks together; a mile and a half more (passing on the route the large Verplanck ice-house) will take him to Broadway, in the village of Verplanck, near the foot of which street, on the shore, occur the limestone and its associated augitic and hornblendic rocks. Thus, in a distance of seven miles, he will see a wonderful diversity of rocks and facts. Possibly he may be convinced, at the end of the walk, that igneous eruption explains everything. But let him go over this ground a second time more carefully, then trace the rocks of Verplanck Point north-eastward, and afterward extend his walks in other directions over the Cortland region, and he may see enough to satisfy himself finally that, although there has been fusion and some eruption, it was not eruption from the earth's deeper recesses, like that which brought up trap (dolerite) through a series of great fissures for a thousand miles along the Eastern Atlantic border, from the Carolinas to Nova Scotia, all of it rock of one kind essentially, but eruption from less depths, not greater than the lower limits of a series of formations that were subjected together to foldings, fractures, and metamorphic change, and mostly far short of this.

IV.—Woodwardian Laboratory Notes.[1]

Part III.—The Bagshot Beds of the Bagshot District.

By W. H. Herries, B.A. Cantab.

THE district to which the following notes refer is that which lies between Bagshot, Woking, Aldershot, Farnborough and Ascot. It consists mainly of heath-land, and seems but little known to geologists; in fact, the only authority for the beds included in this area is Professor Prestwich, who, in his paper on the Bagshot Beds [Q.J.G.S. vol. iii. (1847), p. 278], has supplied all the information about the district that is at present known. He divided the beds

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[1] Continued from Decade II. Vol. VII. 1880, p. 458.

into an Upper Sandy series, a Middle Clayey series, and a Lower Sandy series. The Middle series he grouped with the Bracklesham of the Hampshire basin. The Upper he placed between the Bracklesham and Barton; our present object is to show that it is more nearly related to the latter.

Upper Bagshot.—This is best exposed in the Foxhills and in Frimley ridges. The series consists entirely of white and yellow sands, with no pebble-beds, by which it is distinguished from the Lower Bagshot sands. Professor Prestwich has recorded a few casts of shells and other obscure remains, chiefly from the cutting through the ridge on the South Western main-line near Frimley Green. I have been so fortunate as to discover a better locality, and have been able to add considerably to his list. This place is the cutting on each side of the tunnel through the ridge in the new Line from Brookwood through North Camp and Aldershot to Farnham. This cutting, which is not marked on the Ordnance Maps, lies between the words "Pirbright Common" and "Mitchet Lake." The section shows nothing remarkable, and is entirely in the Upper Bagshot. It consists of loose yellow sands, with one or two whiter and rather harder bands, capped by drift gravel. The fossils occur either loose in the sand, or imbedded in small irony concretions, which lie scattered all through the bed. From this cutting, and from the refuse heaps on the side, I have been able to secure a fair collection of fossils, though nearly all unfortunately are in the state of irony casts. This renders specific identification difficult, but Mr. Tawney and Mr. H. Keeping, of the Woodwardian Museum, Cambridge, have kindly identified for me the following. The abundance or paucity of their occurrence is indicated by letters, while it is indicated within brackets whether the form occurs at Barton or Bracklesham, or both.

v.c. *Dentalium*, sp. (like a large undescribed Brook species).
c. *Solarium bistriatum* ? (L. Eocene).
——— *canaliculatum* ?
c. *Phorus*, two species.
Littorina, sp.
v.c. { *Natica labellata* ? (both).
——— *ambulacrum* (both).
——— *patula* (both). }
——— sp. like *N. conoides* (Bk. only).
v.c. *Turritella imbricataria* (both).
——— sp. or *Niso* ?
c. *Rostellaria rimosa* (both).
Fusus, sp., perhaps young of *F. longævus* (both).
Voluta, sp.
Cancellaria, sp.
c. *Terebellum*, sp.
r. *Volvaria acutiuscula* (Barton only).
Bulla attenuata (both).
——— sp.
v.c. *Ostrea flabellula* (both).
Ostrea, sp.
Pecten triginta-radiatus ? ? (Bk. only).
c. ——— *carinatus* ? (Barton).
c. *Cardita sulcata* ? (Barton).
Nucula similis.
c. { *Corbula ficus* ? (Barton only).
——— *pisum* (both). }
——— *striata* (both).
c. *Tellina scalaroides* (Brook only ?).
——— sp.
c. *Crassatella sulcata* ? (Barton only).
c. *Cytherea*, more than one species.
Cardium turgidum ?
——— sp.
Protocardium, sp.
Lucina mitis (both).
——— *Rigaultiana* (Barton only).
r. *Clavagella coronata* (Barton only).
Many casts of bivalves indeterminable.
r. *Serpulorbis Marshii* (both).
Wood.

A consideration of the above list tends to show a position rather above the Bracklesham, and seems to assign to the Upper Bagshot of the London basin a position almost equivalent to the Barton of the Hampshire basin. It would also indicate that that part at least of the Hampshire basin Upper Bagshot which, at its summit immediately under the freshwater Lower Headon at Hordwell, contains *Oliva Branderi* and *C.* (*Vicarya*) *concavum*, is a distinct and probably higher horizon. There are many exposures of the Upper Bagshot in the ridges, but at only three others have I found fossils, and these fossils are not to be compared in state of preservation with those in the Tunnel Hill cuttings. These places are the old cutting on the main line where Prof. Prestwich found his specimens (*loc. cit.* p. 393); a new cutting at Crawley Hill in the new railway from Frimley to Ascot, and a road cutting on the side of the hill near Heatherside nursery gardens. It is remarkable that the fossils should be so comparatively well preserved only in one place, while in the others they are usually friable pseudomorphs of iron sand, often hollow, and only having the general shape of the fossils they represent, no markings being preserved.

Middle Bagshot.—On good fossil evidence this was referred by Prof. Prestwich to the Bracklesham, and sections were given by him in the paper referred to above of the chief fossil localities, viz. Goldsworthy Hill and Chobham Place. Strange to say, at the former of these places I have not been successful in finding any fossils, though I have carefully searched as much of the cutting as is still exposed, it being now much overgrown. A fine section is, however, now open in the new line between Frimley and Ascot, about a mile from Ascot station.

The beds shown are in descending order.

Upper Bagshot ?	1. Yellow sands	feet	inches.	
Middle Bagshot	Iron band	0	1	
	Yellow sands	2	6	
	Pebble-bed often in a greenish matrix	0	10	
	Yellow, white, red, laminated sandy clays	10	0	about
	Pebble-bed	0	2	
	Yellow and liver-coloured laminated sands	3	0	
	Green sand, fossiliferous yellow sand	12	0	about
Lower Bagshot	Yellow sand.			

In the Greensand bed fossils occur in a particular band. The following have been found here:—

Phorus, sp.
v.c. *Natica*, sp.
c. *Fusus longævus.*
Turritella, sp.
Voluta, sp.
v.c. *Ostrea flabellula.*
——— sp.

c. *Pecten corneus.*
v.c. *Corbula gallica.*
v.c. *Cardita planicosta.*
——— *acuticosta.*
c. *Cytherea obliqua* ?
Cardium semigranulatum.
——— *porulosum.*

The fossils are invariably casts and often curiously distorted. In this section the pebble-beds are very thin, but towards the east they swell out. In a shallow road cutting near the Queen's Clump, about half a mile west of Long Cross, the fossiliferous greensand again appears, and is there capped by about six feet of pebbles. Near Ottershaw the pebble-beds must be ten feet or more, and are always in the greensand. The pebbles are mostly flint, but I have found a quartz pebble. The fossils, it should be noted, are always in the greensand; fossil localities are, the railway cutting described above, the road cutting near Long Cross, a ditch cutting in the road near Fellow End, cuttings S. and W. of Chobham Place, and at Knowle Hill; all these places lying north of the Upper Bagshot ridge. Prof. Prestwich mentions besides Goldsworthy Hill near Woking, and the cutting at Shapely Heath near Winchfield, but at neither of these places have I been successful in finding fossils.

Lower Bagshot.—One of the best exposures of these beds in this district is at St. Anne's Hill near Chertsey. The upper part of this hill is one large pebble-bed, the lower consists of light-coloured sands with thinner pebble-beds. A large sand pit has been opened on the north side. In the refuse heaps of this pit I noticed some large blocks of white sandstone exactly like the Sarsen stones found in the drift gravel. I did not see any in situ in the pit, but the workmen told me that they occurred irregularly in the sand, and they seemed to be merely consolidated portions of the sand itself. Some of the pebble-beds are likewise solidified and form hard conglomerates. This is the only instance of stone resembling Sarsen stone that I have seen in the Bagshot beds. Professor Prestwich states that Sarsen stones occur in the Upper Bagshot just below the drift gravel: with this however I cannot altogether agree; for though I have examined many Upper Bagshot pits, I have never seen a Sarsen stone in the Upper Bagshot beds themselves; it is true I have seen hundreds in the overlying drift gravel.

The pebble-beds of the Lower Bagshot are chiefly flint, though sometimes pieces of ironstone are found, probably from the Lower Greensand.

I have found no fossils in the Lower Bagshot except vegetable remains, which are generally obscure. A bed in a pit near Goldsworthy Hill, consisting of light-coloured sandy foliated clays, lying just above the Lower Bagshot Sands, is full of stalk-like impressions. In the Sarsen stones carbonaceous pipes are often common.

V.—On a Shell-bed at the Base of the Drift at Speeton near Filey, on the Yorkshire Coast.

By G. W. Lamplugh.

Introduction.—A few miles north-west of Flambro Head the Chalk, after grandly edging the sea with sheer cliffs of over 400 feet, recedes inland; its steep high scarp making at first an angle of about 20° with the coast.

Between these Chalk Wolds and the Oolitic range opposite is the broad flat Vale of Pickering, which is based on soft clays and shales belonging to the Neocomian and Kimmeridge series, deeply covered with glacial and modern alluvial deposits. Where intersected by the sea, the Vale has a width of about four miles, but expands inland into a broad plain; to contract again beyond Malton into a mere cutting, by which the Derwent has forced its way through the Oolitic hills into the plain of York. At its eastern end the glacial deposits are of great thickness, but slope away inland, and are soon overlaid by the low-lying modern peats and silts; and it is this drift barrier alone which prevents the Derwent from now flowing directly into the North Sea; as it would seem to to have done in Pre-Glacial times.

The little village of Speeton is perched on the edge of the chalk-scarp just after it has left the coast; and below it are the sections which have already made the name familiar to geologists. On its right, at the base of the high cliffs, is the well-known outcrop of Red Chalk, nowhere so well seen; whilst the low cliffs immediately below the village consist chiefly of that mass of clays and shales whose slipped and intricate sections have been so ably deciphered by Professor Judd,[1] who has found in them representatives of the Neocomian, Portlandian, and Kimmeridge ages.

Nor is the interest of these cliffs even now quite exhausted, for, though as yet little noticed, at first overlying but soon overlapping and hid by the Secondary clays, are some of the finest and most complete drift sections of a coast famous for its drift sections; and, at the base of the drift, is a bed of sand with shells; to which I would now draw attention.

Description of the bed.—The first, and, so far as I am aware, the only previous notice of this bed, is contained in the 3rd edition of Prof. Phillips's "Geology of Yorkshire, Part I.," where he gives the following brief account of it (p. 100), which will serve to describe its position:—"Whilst searching these (*i.e. the Neocomian*) cliffs in the autumn of 1855, I discovered a considerable bed of shelly sand under or in the lower part of the drift at a considerable height above the shore, and took measures and bearings to recover the spot. The shells then found were all *Dimyaria* (*Cardia, Tellinæ, Amphidesma Listeri, Mactræ* and *Psammobia*), shells of a sandy shore; they were often found with valves united. Only living species were found, unless a very large *Cardium*, much resembling *C. Parkinsoni* of the Crag, were really of that species. This shell-bed, re-examined in 1872 by Mr. J. E. Lee and myself, yielded the same shells, with a portion of *Cyprina islandica*[2] and a *Littorina* with colour bands preserved.

"The situation is nearly over the contorted pebble-beds, at a height of 105 feet from the shore, the drift rising here to 160 feet. The shelly sands are seen to be covered by a clay-drift with chalk

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[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 218.

[2] I think it doubtful whether this was really obtained from the shelly sands, but had not rather been washed on to their surface from the overlying Boulder-clay; for it is hardly likely that a *fragment* of so strong a shell as *C. islandica* should be found, when such comparatively delicate shells as *Scrobicularia piperata* have been deposited unbroken; for though these shells are now almost always found so crushed as to make it difficult to recognize them, this has been done after they were buried, for the fragments always remain together and are in no wise rolled. Most careful search, also, has failed to reveal to me another particle, whereas worn fragments of this shell are rather abundant in the clay above, which is constantly washing down and masking the sand bed. As Prof. Phillips considered the bed of Drift-age, he would not consider this of much import.

fragments in unusual abundance [1] immediately over the sands. These are 10 feet thick; [2] they are traced downwards to within 8 feet of the Kimmeridge Clay; but this junction has not been actually seen, and it is supposed that a small band of drift-clay may underlie the shells. It is obviously a portion of the old sea-bed, and may be compared to the so-called Crag at Bridlington and the shell-bed found by Sir C. Lyell at the base of Dimlington Cliff.

(*Here follows a rough sketch of the bed.*)

"About forty years since, Mr. Bean showed me some of these shells, and I was struck by the resemblance to Crag, both of the shells and the yellow sandy matrix; but my friend, supposing them to have been collected by birds,[3] did not inform me of the locality, and appears not to have made further research. This is, I believe, the only notice which has been published, though soon after my examination in 1855 a communication on the subject was made to the Ashmolean Society at Oxford. Though, as I believe, only one bed of these shells occurs, the slipping of the cliffs has made a kind of double escarpment, so that when first seen in 1855, there was a large exposure; and but for other occupations, measures would have been taken to excavate largely, and obtain a more complete description of the deposit."

To those acquainted with these cliffs or with Prof. Judd's paper on the "Speeton Clay," it may assist the above account of the position of the bed, as the contorted pebble beds (Portlandian) are never now seen, to add that this exposure is on the ridge which divides "Middle Cliff" from "New Closes Cliff," on which, when seen in profile, the slip mentioned by Prof. Phillips makes a well-marked terrace.[4]

When I first examined it two years ago, I soon saw that there was a much better exposure than in Prof. Phillips' time, the slip which causes it having gradually sunk to a lower level, thus baring a greater thickness of the sand, which is also seen to change its character in its lower part, and to contain three or four species of shells which are absent from the upper part of the bed. In fact, so low had the terrace sunk, that I was able with the help of a spade to demonstrate the non-existence of the supposed underlying band of Boulder-clay. At the time of writing the slip shows signs of a general break-up; so that, unless a fresh mass come down from above, we may hope shortly to have a perfectly clear section down to the Neocomian.

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[1] This was probably really the chalky gravel presently to be described as capping the bed, with a masking of Boulder-clay.

[2] I found them to be 14 feet.

[3] A source of much trouble in collecting from the drifts on the coast; for the sea-birds carry molluscs into the cliffs to break and eat, and the fragments get washed into the clays and gravels.

[4] Any one looking for this bed might find it difficult to hit upon, owing to the before-mentioned masking by Boulder-clay washed from above, so that it exactly resembles Boulder-clay itself. Until its position was pointed out to me by F. A. Bedwell, Esq., of this town, who had re-discovered it, I was unable to find it from this reason.

Instead of Boulder-clay, I found a slight thickness of gravel of a purely local character to underlie the shelly sands, consisting entirely, as far as I could see, of much stained Red and White Chalk pebbles, Neocomian nodules, plates of Upper Kimmeridge shale, with many fragments of fossils, chiefly *Belemnites,* not much rolled, from the Red Chalk and Neocomian, and an occasional Oolitic pebble. I have also found in the bed itself a pebble of jet from the Upper Lias. This gravel rested directly on the lower part of the Lower Neocomian, the *Astierianus* band of Prof. Judd, containing *Belemnites lateralis* and *Exogyra sinuata* in abundance; and not on Kimmeridge Clay.

The section from the cliff-top to the Neocomians then stood as follows:—

CLIFF TOP.
Reddish Boulder-clay, 30 feet.
Sand and Gravel, 5 feet.
Dark Boulder-clay, 10 feet.
Sandy Shell bed, 16 feet. With thin gravel above and below.
Lower Neocomian.

If the top red clay be traced northward, it is found to separate into two well-marked divisions, the upper of which is red and the lower brown, with gravels and sands, sometimes of great thickness, between them. Here, however, they are mingled, and no line can be seen. The Boulder-clays, except the top red clay, contain shell fragments sparingly scattered through their mass, which differ widely, however, from those contained in the bed below; *Dentalium,* two or three species of *Astarte, Cyprina, Mya, Saxicava,* etc., occurring amongst others, and of course the ubiquitous *Tellina Balthica,* which never fails a Yorkshire Post-Tertiary shell-list.

The shell-bed itself is made up as follows:—

	Thickness. ft.	ins.
Fine chalky gravel		6
Dark clayey sand; few shells. Soft yellow sand with indurated lumps: many shells, *Cardium edule, T. Balthica, Scrobicularia piperata;* passing into	9	2
Dark blue-black muddy sand, with a fœtid odour: with a few pebbles and plates of Kimmeridge shale: many shells —*T. Balthica, C. edule, Utriculus obtusus, Hydrobia ulvæ,* plentiful; *Littorina littorea* and *L. rudis,* rare; at the very bottom—*Mytilus edulis*	5	1
Gravel of Red and White Chalk, broken Neocomian fossils, etc. ... ... about	1	6
	16	3

The shells are in so bad a state of preservation that it is very difficult to remove them. More especially is this the case in the upper part of the bed, where the water which oozes out from the soaked sand below percolates more freely.

The following species have been obtained:[1]

Tellina Balthica.
Psammobia sp. (fide Phillips).
Mactra sp. (,, ,,).
Scrobicularia piperata.
Cardium edule.
Mytilus edulis.
Littorina littorea.
,, *rudis*, var.
Hydrobia ulvæ.
Utriculus obtusus, var. *pretenuis.*

As noticed by Prof. Phillips, the bivalves generally occur with valves united; but they are not often in the attitude of life; usually having the umbos upwards, and with the valves gaping open. Single shells do occur, and also an occasional imperfect valve; but, on the whole, they show very few signs of wave action, and appear to have been left by quietly receding tide-waters on a muddy flat. Another proof of the quietness of the waters is the sharply-fractured and unabraded state of the broken *Belemnites*, which, with a few other pebbles, are sparsely scattered through the lower part of the sands.

That the bed accumulated slowly is shown by the difference in fauna and lithological character between the upper and lower parts of the deposit; the result of some slight and gradual change in the surrounding conditions, probably a slight deepening of the water with an accelerated current.

The shells confirm the idea strongly suggested by the shape of the ground that the beds were formed at the mouth of a quiet tidal estuary. When the waters of the sea stood at the level indicated, the glacial and later beds which now cumber the Vale being then unformed, what is now the Vale of Pickering would then be a wide, shallow, land-locked estuary receiving the copious drainage of the Eastern Moorlands, which now flows through the narrow gorge at Castle Howard to join the Ouse. The piece of light jet found in the deposit tells of distant erosion in the Upper Lias, having doubtless been brought down by the old river from the higher reaches of the valley, north of Pickering.

Unfortunately the above limited shell-list yields us little evidence as to the age of the bed. *Tellina Balthica*, however, shows that it cannot be so old as the Red Crag; and as it will be shown to underlie the oldest Yorkshire Glacial deposit, its age must lie somewhere between then and early Glacial times.

Its Extent and Stratigraphical Relations.—By far the clearest and best exposure of these shelly sands is the one described above, on the dividing ridge between "Middle" and "New Closes Cliff," about half a mile north of Speeton Gap (where the Chalk ends). On the south side of this ridge they end abruptly, having been carried away by a huge slip, and portions of them may sometimes be seen down at the level of high-tide; but beyond this, though I have carefully sought over the slipped ground up to the foot of the chalk scarp, I have not been able to find any traces of them. The accompanying chalk-gravel, rapidly increasing in thickness and in roughness as we approach its parent-slope, can be followed through-

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[1] I have to thank Dr. Gwyn Jeffreys for his kindness in examining these shells for me.

out, but without further signs of shelly sand, which probably therefore thins out as the Neocomian clays rise to a higher level, and we approach the high-water mark of the old estuary. It is, indeed, tolerably certain, that in this exposure the beds have reached their greatest development, for northward from this point the underlying Secondary clays show a steep denudation slope, which reaches the beach at the north end of New Closes Cliff; so that if all the drift were removed, a broad flat terrace of Neocomian clays, coinciding perhaps with the tidal flat of the old estuary, would stretch along under the chalk-scarp. And, as might be expected, it is on the crest of this terrace that the sands are thickest, for in the deeper central portions of the valley the current from the land would probably run too strongly to allow sand-banks to form.

I have found traces of the sands here and there amongst the slips across New Closes Cliff, following the denudation slope of the Secondaries till they reach the beach-line, where the sands may be seen at the cliff-foot when the sand and shingle of the beach happen to be removed from the base of the cliff. The distinction between upper and lower parts still holds, but the sands are only about two feet thick, and shells are not at all plentiful.

Northward beyond this they may be seen at intervals between slips, being often little better than a re-arranged form of the Speeton clay, till "The Gill" is reached, where they finally disappear from the cliff-foot.

In May, 1879, however, there was a very interesting exposure on the beach, nearly opposite the village of Reighton, about a mile north of "The Gill," and here again I obtained traces of the deposit, and also had direct evidence as to its being older than any Yorkshire Boulder-clay.

As has been shown, in the chief exposure, in New Closes Cliff, the shelly sands are overlaid by a dark Boulder-clay, above which a red Boulder-clay is seen—a parting of gravels occurring between them. I have also mentioned that, if the upper clay be traced northward, it is found to consist really of two separate clays, the division here having been obliterated. The top clay[1] I believe to be the northward extension of the "Hessle Clay" of Holderness. The other two form the "Purple Clay" of Messrs. Wood and Rome,[2] but I have also endeavoured to show[3] them to be really distinct, and as good divisions as any of those now recognized, and which may be readily traced wherever the "Purple Clay" is well developed, either north or south of Flambro. The shell-bed is therefore overlaid here by what we may call the "Lower Purple Clay." The exposure on the beach, however, revealed older divisions. It extended nearly 500 yards, and had a varying width of about 30 yards. In it the following beds were seen, appearing to dip slightly towards the cliff:—

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[1] Proc. Yorkshire Geol. Soc. for 1879 (On the Divisions of the Glacial Beds in Filey Bay).

[2] Quart. Journ. Geol. Soc. vol. xxiv. p. 147.

[3] V. supra.

Commencing from the high-water side we first crossed over—

1. Boulder-clay, belonging to the "Lower Purple," which is continued into the cliff.
2. Bluish Boulder-clay, with many shell fragments, and with streaks of fine blue mud containing many crushed shells. Fauna that of the Bridlington glacial shell-bed.
   This was undoubtedly the "Basement-clay" of Messrs. Wood and Rome.
3. Brown Boulder-clay, full of stones; no shells. (Not yet seen elsewhere on the coast, the bottom of the Basement-clay being rarely visible.)
4. Band of fine Chalk-gravel, with a seam of sand.
5. Thin band of re-arranged Kimmeridge shale, with broken fossils.
6. Highly contorted Upper Kimmeridge shale,

Here it is tolerably certain that the sandy beds are represented by the few inches of dark muddy sand in the fine chalk rubble (No. 4), for we have already seen how rapidly they thinned after leaving the edge of the old hollow, probably owing, as before suggested, to the strength of the current in the middle of the valley. I did not see any shells; but as all those found in the chief exposure were shore species, and this exposure but small, this did not surprise me.

No. 3 seems to be the remains of an older clay than any before noticed in Yorkshire, but I know of no other case in which the bottom of the "Basement-clay" presents itself for investigation. It may well be the result of a land-glaciation preceding the flow which formed the overlying shelly blue clay, which appears to have come in main from seaward.

There is thus a curious unconformity in the beds *overlying* the shell-bed whose preservation is a remarkable instance of the irregularity of glacial denudation.

Age of the Deposit.—As the so-called "Basement-clay" is now believed, and probably rightly, to be of the age of the Cromer Tills, it follows that the bed of shells at Speeton is older than that deposit. May it not then, on good evidence, be correlated with some part of the marine Pre-Glacial beds of Norfolk?

Beds of similar Age in the Neighbourhood.—There is, almost continuously, on the top of the Chalk from its first appearance, north of Bridlington, to Flambro, a band of fine gravel of varying thickness, consisting wholly of chalk. This gravel sometimes admits sand-streaks, which, at the bottom of the Danes Dyke Valley, a narrow old Pre-Glacial hollow three miles north of Bridlington, and in other places, thicken out into well-bedded sands and sandy silts. These, at Danes Dyke, are seven feet in thickness, and though as yet I have not found any shells or other remains in them, they are probably of about the same age as the Speeton bed. It is rather curious that at Danes Dyke these sands show the same division into dark blue below and yellow above.

Some years ago the remains of some large elephantine animal were found in the cliff about a mile and a half north of Bridlington, and as far as I can learn they appear to have been obtained from the horizon of this bed, but I have not been able to obtain any exact information on this point.

VI.—NOTE ON THE CARBONIFEROUS SYSTEM IN BRITAIN.

By Prof. T. RUPERT JONES, F.R.S., F.G.S.

IN comparing the relative *thicknesses* of the Welsh-English and the Scotch Carboniferous series for lecture notes, I have found it difficult to obtain from books definite statements on this point as regards some groups of these strata in Scotland. After considerable reading I gather the following information.

A general section of the Carboniferous strata of Scotland shows this arrangement;—

	Upper Coals.
	Moor Rock or Roslyn Sandstone.
Carboniferous Limestone Series	Upper Limestones.
	Lower Coals with Limestones.
	Lower Limestones.
	Calciferous Sandstone Series.

In the "Geological Survey Memoir on the Neighbourhood of Edinburgh" Mr. Howell gives the following average thicknesses for the Mid-Lothian Coal-field (p. 73):—Coal-measures 1220 feet; Millstone-grit 340 feet; Carboniferous Limestone series (including Upper Limestones 650′, Edge Coals 600′, Lower Limestones 340′) 1590 feet. The thickness of the Lower Carboniferous strata (Calciferous Sandstone) is not given in Prof. Geikie's portion of the Memoir, but his description of the series proves it to be of great amount.

In the "East-Lothian Memoir" Prof. Geikie estimates the thickness of the Calciferous Sandstone series at 1350 feet, as seen on the coast section between Siccar Point and Thorntonloch.[1] The thickness of the Carboniferous Limestone series is not mentioned in this Memoir, though the usual arrangement of the Upper and Lower Limestone groups, with profitable Coal-measures between them, is fully described.

In later Memoirs of the Geological Survey of Scotland many details of the local thickness of the subdivisions of the Carboniferous Limestone series and of the Coal-measures are given; but no estimate of the aggregate thickness of the formations is ventured on.

The grouping of the strata in the West of Scotland appears to be similar to that of the Eastern side, although the Lower Carboniferous series has not the same *facies* as that in the East. In the useful "Catalogue of the Western Scottish Fossils." published by Members of the Geological Society of Glasgow for the British Association Meeting of 1876, the thicknesses of the different members of the system, in Central and Western Scotland, are thus stated (pp. 31 and 32):—

	Upper Coals and Ironstones	1500 to 1800 feet.
	Millstone-grit Series	480 ,, 900 ,,
Carboniferous Limestone Series.	Upper Limestone Series	480 ,, 600 ,,
	Lower Coals and Ironstones	420 ,, 600 ,,
	Lower Limestone Series...............	600 ,, 1200 ,,
	Calciferous Sandstone Series..........	1500 ,, 1800 ,,
		4980 ,, 6900 ,,

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[1] "Geol. of East Lothian," 1866, p. 30.

In Fife the Lower Carboniferous, or Calciferous Sandstone, series appears to be abnormally thick (3900 feet according to Mr. J. W. Kirkby's paper in the Quart. Journ. Geol. Soc. No. 144, p. 559), compared with the estimate given by Prof. Geikie for the same series in East-Lothian. In a letter received from the author of the above paper, it is stated that a general section of the Fifeshire Carboniferous series (which, besides being essentially complete, is of interest on account of its being the most northerly exposure of this formation in Britain) in all probability is nearly as follows:—

		feet.	feet.
I. Coal-measures	1. Upper Red Beds	900	2300
	2. Lower Measures with workable coals	1400	
II. Millstone-grit series, or Moor Rock		....	300
III. Carboniferous Limestone Series	1. Upper portion with limestones	400	1600
	2. Middle portion with workable coals..............	800	
	3. Lower portion with limestones	430	
IV. Calciferous Sandstone[1] series		....	4000
			8200

The English series of Carboniferous strata immediately south of the Border does not apparently differ much from the Scotch. In a sketch of the Geology of Northumberland, by the late Mr. George Tate ("Transact. Nat. Hist. Soc. Northumberland and Durham," 1868, vol. ii. pp. 6—18), the Carboniferous strata are grouped as below:—

		feet.	feet.
I. Coal-measures		....	2000
II. Millstone-grit		....	500
III. Mountain Limestone..	1. *Calcareous Group*, with many beds of limestone ..	1700	2600
	2. *Carbonaceous Group*, with seven workable coals and a few limestones	900	
IV. Tuedian Group		....	1000
			6100

The lowest or Tuedian group of this series consists of "grey, greenish, and lilac shales, thin beds of argillaceous and cherty limestones, and a few buff magnesian limestones, and of sandstones and slaty sandstones." Several of the shales and sandstones also are calcareous. The characteristic fossils are *Stigmaria*, *Lepidodendron*, and *Sphenopteris*; *Rhizodus* and other Fishes; Molluscs allied to *Modiola*; Entomostraca; *Spirorbis*; and occasionally such marine forms as *Orthoceras*, *Murchisonia*, and *Pleurotomaria*. These features are pretty much those of the Calciferous Sandstone on the other side of the Border, with which series of strata Mr. Tate's group is identical.

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[1] Basement beds not seen.

In comparison with these north-country sections, the Welsh-English series, taken generally, offers:—

		feet.	
Upper Carboniferous.	Coal-measures..	10,000	Upper or Ardwick series. Middle or Pennant series. Lower or Gannister series.[1]
	Millstone-grit...	1,000	
Lower Carboniferous.	Carboniferous Limestone ..	1,500	1. Up. Limestone-shale or Yoredale series. 2. Mountain, Scar, or Great Limestone. 3. Lower Limestone-shale.
		12,500	

Of course, the question as to how far the whole series of the two regions, or members of the series, may be conterminous and contemporaneous, or merely analogous and homotaxeous, is not regarded in this notice.

REVIEWS.

An Index Guide to the Geological Collections in the University Museum, Oxford. By Professor Prestwich, M.A., F.R.S., etc. (Oxford, Clarendon Press, 1881.)

SINCE the "Notices of Rocks and Fossils in the University Museum," by the late Prof. Phillips, which has long been out of print, many additions have been made, portions of the collection re-arranged, and a large number of specimens have been carefully named and located, so that a new and thoroughly revised catalogue was essentially requisite, and this has now been supplied by Prof. Prestwich. Without giving too much detail, or troubling the reader with an array of specific names, this guide gives a general account of the arrangement adopted, in which the author has endeavoured to show, besides the position of the specimens in the Museum, their relative place in systematic classification and geological age. The order in which the collections are described is (1) the Rocks and their constituents, and (2) the Organic remains or the Palæontological portion. The former include the chief building and ornamental stones of the British Islands (of which the use in the Museum itself furnishes a good example), as well as notices of other Igneous, Metamorphic, and Sedimentary Rocks; a table showing the succession of the last in the British area is given at p. 21. A brief description of the classification of the minerals concludes this part.

The second portion treats of the general palæontological series of the Palæozoic and Secondary strata, and of the Tertiary and Quaternary rocks and fossils (pp. 25-48), together with descriptions of the local collections of the typical fossils of the Oxford district (pp. 49-58), as well as of the collections illustrative of the range and variations in time of particular classes of fossils, and to which the diagram at p. 64 is a valuable supplement, as

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[1] In his memoir "On the Classification of the Carboniferous Series" (Quart. Journ. Geol. Soc. vol. xxxiii. pp. 613, etc.), Prof. E. Hull gives his reasons for grouping the *Gannister*, *Millstone*, and *Yoredale* series as the Middle Carboniferous."

showing clearly the order in time of the succession of life on the globe.

Both the visitor and student will find this work a concise and handy guide to the rocks and fossils contained in the Museum, which, among many interesting forms, contains the classical specimens collected by Dr. Buckland, and the fine series of Saurian remains obtained by Prof. Phillips and described in his "Geology of Oxford and the Valley of the Thames." J. M.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

I.—ANNUAL GENERAL MEETING.—February 18th, 1881.—Robert Etheridge, Esq., 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 1880, the Council announcing with much satisfaction that the financial depression under which the Society had been suffering during 1878 and 1879 had proved, as was anticipated, only temporary, and that the Society is now in a very prosperous condition. The Council's Report also announced the publication of the new Catalogue of the Library, which, although considerably larger than was at first expected, will be issued to the Fellows at the price originally fixed for it. The Report further announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society.

In presenting the Wollaston Gold Metal to Prof. P. MARTIN DUNCAN, M.B., F.R.S., F.G.S., the PRESIDENT addressed him as follows:—

Professor DUNCAN,—It is with no ordinary pleasure that the Council have awarded to you the Wollaston Medal, the highest honour that it is in their power to bestow, in recognition of the valuable services which you have rendered during so many years to the advancement of Geology, and especially of Palæontology; and I may add that it is equally productive of gratification to me that this honour is to be formally conferred upon you by my hands. Since the year 1863 palæontologists have been indebted to you for no fewer than twenty-six memoirs relating to the history, structure, and distribution of the fossil Actinozoa, a group which you have made peculiarly your own by long-continued and most careful researches. Further, you have enriched the publications of the Palæontographical Society with several most important treatises on British Fossil Corals, supplementary or, rather, perhaps, complementary to the classical Monograph of MM. Milne-Edwards and Haime. These labours alone, and the value of their results, might have justified the Council in awarding you the Wollaston Medal; but besides your researches upon the Actinozoa, we have to point to several important papers upon the fossil Echinodermata, to others relating to subjects of Physical Geology (also freely touched upon in your more special memoirs), and particularly to your exceedingly important work in connexion with the Geological Survey of India, in describing the fossil corals of that Peninsula, and discussing the questions of both zoological and geological interest which naturally arise out of the study of those organisms. Few, indeed, of our Fellows are in a better position to appreciate your valuable labours than myself; scarcely a day passes that I have not occasion to consult one or more of your contributions; and the more I consult them the more I am convinced of their value. Patiently and unobtrusively, for nearly twenty years, you have followed out the line of research necessary for the fulfilment of your self-imposed task; you have sacrificed the advantages of professional life to devote your energies to the advancement of science; for seven years (from 1864 to 1870) you gave the Society the benefit of your services as one of its Honorary Secretaries, and for two years (1876—1877) you worthily occupied the Presidential Chair. Such considerations as these would not alone, perhaps, have warranted the award of the Council; but the recollection of such services rendered to the Society is hardly out of place, as supplementing those more generally appreciable merits upon which the award was really founded. On all accounts it is with much pleasure that I hand to you the Wollaston Medal.

Professor DUNCAN made a short speech acknowledging the pleasure he felt in receiving the Medal.

The PRESIDENT then presented the Murchison Medal to Prof. ARCHIBALD GEIKIE, F.R.S., F.G.S., and addressed him as follows :—

Prof. GEIKIE,—If any one Fellow of our Society more than another could be selected to receive the Murchison Medal for his valuable contributions to geology, it would be yourself; since no man living has contributed more to the advancement of that science which it is the special object of our Society to cultivate and diffuse. Your labours in the field connected with your duties as Director of the Geological Survey of Scotland, your learned and valuable contributions to the Journal of our Society, the Transactions of the Royal Society of Edinburgh, and the Glasgow Geological Society, and other publications too numerous to mention, eminently qualify you to be the recipient of the Medal founded by your late chief and friend Sir Roderick Murchison. To enumerate your contributions to the literature of the geology of Scotland, or your many important writings connected with our science, would lead me too far—some thirty papers, besides educational works, have resulted from your industry and knowledge. Your able paper alone, on the "Old Red Sandstone of Scotland," published in the Transactions of the Royal Society of Edinburgh, would entitle you to the highest consideration of the Society. Able, indeed, are other contributions, especially those "On the Chronology of the Trap Rocks of Scotland," "On the Date of the last Elevation of Central Scotland" (in vol. xviii. of our Journal), "On the Phenomena of Succession amongst the Silurian Rocks of Scotland" (Trans. Glasgow Geol. Soc. vol. iii.), and "On Earth Sculpture." The Council believed, too, that it would be gratifying to you to receive a mark of their esteem and sense of your untiring labours, the Medal founded by one with whom in earlier life you were closely associated, and whose endowed Chair of Geology in the University of Edinburgh you have been the first to fill.

Prof. GEIKIE expressed, in reply, his gratification at the gift of the Murchison Medal.

The PRESIDENT next handed the Lyell Medal to Mr. WARINGTON W. SMYTH, F.R.S., F.G.S., for transmission to Dr. J. W. DAWSON, F.R.S., F.G.S., of Montreal, and addressed him as follows :—

Sir Charles Lyell, in founding the Medal that bears his name, intended that it should serve as a mark of honorary distinction, and as an impression on the part of the governing body of the Society of their opinion that the Medallist has deserved well of science. I need hardly say that the Council, in awarding the Lyell Medal to Principal Dawson, have done so with a sincere appreciation of the high value of his truly great labours in the cause of Palæontology and Geology. When I refer to his published papers, I find that they number nearly 120, and that they give the results of most extensive and valuable researches in various departments of geology, but more especially upon the palæontology of the Devonian and Carboniferous formations of Northern America. No fewer than 30 of these papers have appeared in the pages of our own Quarterly Journal. Considering the nature of these numerous contributions, the Council would have been fully justified in awarding to Dr. Dawson one of its Medals, upon the sole ground of the value of their contents; but these are far from representing the whole of the results of his incessant activity in the pursuit of science. His 'Acadian Geology,' 'Post-pliocene Geology of Canada,' and 'Fossil Plants of the Devonian and Upper Silurian of Canada,' are most valuable contributions to our knowledge of North American Geology; whilst in his 'Archaia,' 'The Dawn of Life,' and other more or less popular writings he has appealed, and worthily, to a wider public. We are indebted to his researches for nearly all our knowledge of the fossil flora of the Devonian and other Precarboniferous rocks of America, and of the structure and flora of the Nova-Scotian coal-field; and finally I must refer especially to his original investigation of the history, nature, and affinities of *Eozoon*. These researches are so well known that they have gained for Dr. Dawson a world-wide reputation; and it is as a slight mark of their esteem, and their high appreciation of his labours, that the Council have awarded to him this Medal, which I will request you to forward to him, with some verbal expression of the feeling with which it is offered.

Mr. Warington W. Smyth then read a letter from Dr. Dawson regretting he was unable personally to be present, and expressing his sense of the honour conferred upon him.

The President then handed the Bigsby Medal to Prof. Morris, F.G.S., for transmission to Dr. Charles Barrois, and addressed him as follows:—

The Council of this Society has selected Dr. Charles Barrois to be the recipient of the Bigsby Medal, and have awarded it to him for his numerous papers and contributions to geological science. Dr. Barrois's chief or most important work (written in the year 1876, and published at Lille) is 'Recherches sur le terrain crétacé supérieur de l'Angleterre et de l'Irlande,' a production almost exhaustive in its description of the Cretaceous rocks of England and Ireland, and of the utmost value to English students of geology. Dr. Barrois in this work has been the first to attempt to arrange the English Cretaceous rocks in Palæontological zones, and eminently has he succeeded in defining and correlating the horizons of France and Britain. He is also the author of a 'Mémoire sur le terrain Crétacé du Bassin d'Oviedo, Espagne,' with a palæontological description of the Echinodermata by Gustave Cotteau. His great industry and untiring zeal for geological science entitle him to the consideration of the Council; and I therefore beg you to forward to him the Bigsby Medal as our recognition of his services, and, according to the wishes of the founder, we look forward to other and equally valuable contributions.

Prof. Morris read a note from Dr. Barrois, in reply, to the honour conferred.

In handing to Prof. J. W. Judd, F.R.S., Sec. G.S., the balance of the Wollaston Donation Fund for transmission to Dr. Ramsay H. Traquair, F.G.S., the President said:—

In handing to you, to be forwarded to Dr. Traquair, the balance of the proceeds of the Wollaston Donation Fund, I have to request that you will inform him of the feeling of the Council, that it is rarely that they can have the opportunity of awarding this fund to a more able and accomplished naturalist than himself. His long-continued researches upon the Ganoid Fishes of the Carboniferous formation have rendered his name eminent in this department of Palæontology. As an accomplished anatomist and zoologist, we must have every confidence that his treatment of these Vertebrates in the memoir which he is contributing to the publications of the Palæontographical Society will be of the most careful and judicious description, whilst the value of this and his other works is vastly enhanced by the beautiful figures with which he illustrates them. Under these circumstances it affords me much pleasure to place in your hands, for transmission to Dr. Traquair, the balance of the Wollaston Fund, which I hope he will receive as some recognition on the part of the Society of the value of his researches, and, at the same time, as a small aid to him in further prosecuting them.

Prof. Judd, in reply, read an appropriate note received from Dr. Traquair, cordially thanking the Society.

The President next presented the balance of the proceeds of the Murchison Donation Fund to Frank Rutley, Esq., F.G.S., and addressed him in the following words:—

For many years you have devoted your time and attention to the microscopical structure of rocks and rock-forming minerals, a branch of scientific research of the highest importance to the petrologist and geologist; and now that our attention is being so much drawn to the structure of the metamorphic and igneous rocks, with a view to a better nomenclature and a revision of old and obsolete views, the Council of our Society believed that in your hands good work would still be carried on; they, therefore, have awarded to you the balance of the Murchison Fund, which I have much pleasure in handing to you in recognition of your past researches, the results of which you have from time to time communicated to the Journal of the Society. Few are more aware than myself of the interest you take in this branch of study, and it affords me much gratification to be the medium of conveying to you the appreciation of the Council and the accompanying fund.

Mr. Rutley suitably returned thanks.

In presenting to G. R. Vine, Esq., one moiety of the balance of the proceeds of the Lyell Donation Fund, the President addressed him as follows:—

A moiety of the balance of the proceeds of the Lyell Geological Fund has been awarded to you by the Council of the Geological Society. In making this award the Council were actuated in part by the wish to express their sense of the value of your researches upon the fossil Bryozoa of the Palæozoic rocks, as evinced especially by your published writings on the Diastoporidæ, an exceedingly difficult group, and in part by their desire to assist you in the further prosecution of your investigations. I have much pleasure in handing to you this small testimony of the appreciation of the Council.

Mr. Vine, in reply, thanked the President for this token of recognition, on the part of the Council, of his labours.

The President then handed to Prof. H. G. Seeley, F.R.S., F.G.S., for transmisson to Dr. Anton Fritsch, of Prague, the second moiety of the Lyell Donation Fund, and said:—

The Council has awarded a portion of the Lyell Geological Fund to Dr. Anton Fritsch, Professor of Zoology in the University of Prague, in recognition of his valuable contributions to palæontology. Dr. Fritsch is an accomplished zoologist, who has enriched his studies of many groups of fossils, invertebrate and vertebrate, with admirable knowledge of existing life. During the last thirty years Dr. Fritsch has published about one hundred and twenty memoirs, many of which relate to palæontology and geology. Besides scattered papers on *Eozoon*, *Callianassa*, and other subjects connected with the fossil fauna of Bohemia, Dr. Fritsch has also published some standard works monographing the fossils of his native land. These comprise the Cretaceous Cephalopods (1872), the Cretaceous Reptiles and Fish (1878), and his great work on the Fauna of the Permian Rocks (still in progress), of which two volumes, devoted to Amphibia, have been issued. These volumes are excellent examples of descriptive work, illustrated worthily, and this award is especially intended to mark the sympathy of the Council with Dr. Fritsch in his endeavours to adequately make known the Permian fauna, and in the hope that the fund may assist him in completing a work which has already taken high rank among palæontological monographs.

Prof. Seeley felt sure that Dr. Fritsch would duly appreciate the honour of the award made him by the Council.

The President then proceeded to read his Anniversary Address, which was devoted to the analysis and distribution of the British Palæozoic fossils, and especially as to their distribution in the successive formations, elucidated by elaborate tables. The Address was prefaced by obituary notices of Fellows and Foreign Members of the Society deceased during the past year, including Dr. J. J. Bigsby, Mr. Searles V. Wood, Prof. Ansted, Dr. C. Nyst, M. Bosquet, and others.

The ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President:* R. Etheridge, Esq., F.R.S., L. and E. *Vice-Presidents:* John Evans, D.C.L., LL.D., F.R.S.; J. W. Hulke, Esq., F.R.S.; Prof. J. Morris, M.A.; and H. C. Sorby, LL.D., F.R.S. *Secretaries:* Prof. T. G. Bonney, M.A., F.R.S.; Prof. J. W. Judd, F.R.S. *Foreign Secretary:* Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer:* J. Gwyn Jeffreys, LL.D., F.R.S. *Council:* H. Bauerman, Esq.; Rev. J. F. Blake, M.A.; Prof. T. G. Bonney, M.A., F.R.S.; W. Carruthers, Esq., F.R.S.; Prof. P. M. Duncan, M.B., F.R.S.; Sir P. de M. Grey-Egerton, Bart., M.P., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, D.C.L., LL.D., F.R.S.; Lieut.-Col. H. H. Godwin-Austen, F.R.S.; J. Clarke Hawkshaw, Esq., M.A.; Rev. Edwin Hill, M.A.; W. H. Hudlestone, Esq., M.A.; J. W. Hulke, Esq., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Prof. J. W. Judd, F.R.S.; Prof. N. S. Maskelyne, M.A., M.P., F.R.S.; J. Morris, Esq., M.A.; J. A. Phillips, Esq.; F. W. Rudler, Esq.; Prof. H. G. Seeley, F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S.; H. C. Sorby, LL.D., F.R.S.; H. Woodward, LL.D., F.R.S.

II.—February 23, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. A letter from Dr. John Kirk, communicated to the Society by the Right Hon. Earl Granville, dated:—

"H.M. Agency and Consulate General,
Zanzibar, December 20, 1880.

"My Lord,—It may be of interest to record the occurrence here of an earthquake shock felt in the island of Zanzibar at 6·58 a.m., mean time, on the morning of the 18th inst.

"Although the shock was very distinct, no damage appears to have been done to any buildings in town.

"It is now twenty-four years since a similar shock has been here noticed; but on the mainland, especially in the vicinity of Ujiji, they are both more common and more severe than at the coast.

"Shortly after the cable was laid between Mozambique and Delagoa Bay, the communication was suddenly interrupted after one of these earthquake shocks, which seems to have caused the falling in of rocks by which the cable was crushed.

"I have the honour to be, etc.,
John Kirk,
H.M. Agent and Consul-General,
Zanzibar."

"The Right Honourable
Earl Granville, etc., etc.,
London.

2. "The Permian, Triassic, and Liassic Rocks of the Carlisle Basin." By T. V. Holmes, Esq., F.G.S.

The district discussed in the author's paper was worked over by him when engaged on the Geological Survey, and consists of those parts of Cumberland and Dumfriesshire which adjoin the Solway. Its southern boundary is, approximately, a line ranging from Maryport to Rose Castle on the River Caldew, and touching the Eden about two miles above Wetheral. On the east and north-east its limits are the immediate neighbourhoods of the junction of the rivers Eden and Irthing, Hethersgill on the Hether Burn, Brackenhill Tower on the Line, and the Border Boundary on the Rivers Esk and Sark; and in Dumfriesshire the small tract south of a line ranging from the junction of Scots Dyke with the Sark on the north-east, to Cummertrees on the south-west.

The lowest bed in this area is the great Upper Permian or St. Bees Sandstone, which occupies a belt of country in the neighbourhood of the outer boundary. Directly above St. Bees Sandstone, in the west of the district, lies a formation consisting of shales with gypsum, which, though 700 feet thick in the neighbourhood of Abbey Town, is nowhere visible, but is known solely from borings, the country west of the Caldew, and of the Eden below the junction of the two streams, being thickly drift-covered and almost sectionless. In the east of the district the St. Bees Sandstone is overlain directly by a soft, red, false-bedded sandstone, called by the author Kirklinton Sandstone, from the locality in which the rock is best seen, as well as its relations to the under- and overlying beds. But while there is no evidence of any unconformity between the St.

Bees Sandstone and the overlying Gypseous Shales in the west, there is evidence of a decided unconformity between the St. Bees and Kirklinton Sandstones in the east. In Carwinley Burn (for example), which runs into the Esk at Netherby, only from 200 to 300 feet of St. Bees stone was seen below the outcrop of the Kirklinton, instead of the 1000 to 1500 feet which probably exist about Brampton on the one hand and in Dumfriesshire on the other. Yet Carwinley Burn affords an almost continuous series of sections, from the (non-faulted) Permian-Carboniferous junction to some distance above the outcrop of the Kirklinton Sandstone. As, in addition, the shales underlying the St. Bees Sandstone are gypseous, both near Carlisle and at Barrowmouth, close to St. Bees Head, the author classed the (Upper) Gypseous Shales as Permian, and the Kirklinton Sandstone as Bunter. Resting unconformably on the Kirklinton Sandstone, in the district between Carlisle and Kirklinton, are the Marls seen on the Eden, between Stanwix and Beaumont, and on the Line between Westlinton and Cliff Bridge, Kirklinton. Their unconformity is shown by the fact that on the Line they rest on the lower, or red, beds, and between Stanwix and Beaumont on the upper, or white, beds of the Kirklinton Sandstone. The Marls have therefore been classed as Keuper. So far as the evidence goes, they appear to be very thin and to extend but a very small distance south of the Eden. Lastly, the Lias appeared to the author to be unconformable to all the beds below, and to rest partly on the Gypseous Shales, partly on the Kirklinton Sandstone, and partly on the Keuper Marls. Of the existence of Rhætic beds there was no evidence, all fossils hitherto found having been determined by Mr. Etheridge (our President) to be Lower-Lias forms. But the Lias-sections are so small and few in number, and the ground so persistently drift-covered, that only a boring could settle the question.

3. "On *Astroconia Granti*, a new Lyssakine Hexactinellid from the Silurian Formation of Canada." By Prof. W. J. Sollas, M.A., F.G.S.

This paper contained a description of a new fossil Hexactinellid sponge from the Niagara chert beds of Hamilton, Ontario. It is the second oldest known example of the Lyssakina. Some remarks were added on the mineral state of the spicules and their association with chert. The author proposed for it the name of *Astroconia Granti*, the former in allusion to the peculiarly spinose character of rays of the sexradiate spicules. The anchoring spicules were described as consisting of a straight shaft with four recurved rays, each having a small bifid spine near the base on the outer surface.

III.—March 9, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Description of Parts of the Skeleton of an Anomodont Reptile (*Platypodosaurus robustus*, Ow.).—Part II. The Pelvis." By Prof. Owen, C.B., F.R.S., F.G.S., etc.

In this paper the author described the remains of the pelvis of

Platypodosaurus robustus, which have now been relieved from the matrix, including the sacrum, the right "os innominatum," and a great part of the left ilium. There are five sacral vertebræ, which the author believes to be the total number in *Platypodosaurus*. The neural canal of the last lumbar vertebra is 8 lines in diameter, and of the first sacral 9 lines, diminishing to 6 lines in the fifth, and indicating an expansion of the myelon in the sacral region, which is in accordance with the great development of the hind limbs. The sacral vertebræ increase in width to the third; the fourth has the widest centrum. This coalescence of the vertebræ justifies the consideration of the mass, as in Mammalia, as one bone or "sacrum," which may be regarded as approaching in shape that of the Megatherioid Mammals, although including fewer vertebræ. Its length is $7\frac{1}{2}$ inches; its greatest breadth, at the third vertebra, $5\frac{1}{2}$ inches. The ilium forms the anterior and dorsal walls of the acetabulum, the posterior and postero-ventral walls of which are formed by the ischium and pubis. The diameter of its outlet is 3 inches, the depth of the cavity $1\frac{1}{2}$ inch; at its bottom is a fossa $1\frac{1}{3}$ inch broad. The foramen is subcircular, 1 inch in diameter. The ventral wall of the pelvic outlet is chiefly formed by the pubis; it is a plate of bone 6 inches broad, concave externally, convex towards the pelvic cavity. The subacetabular border is 7-8 lines thick; it shows no indication of a pectineal process, or of a prominence for the support of a marsupial bone. The author remarks that of all examples of pelvic structure in extinct Reptilia this departs furthest from any modification known in existing types, and makes the nearest approach to the Mammalian pelvis. This is shown especially by the number of sacral vertebræ and their breadth, by the breadth of the iliac bones, and by the extent of confluence of the expanded ischia and pubes.

2. "On the Order Theriodontia, with a Description of a New Genus and Species (*Ælurosaurus felinus*, Ow.)." By Prof. Owen, C.B., F.R.S., F.G.S.

The new form of Theriodont reptile described by the author in this paper under the name of *Ælurosaurus felinus* is represented by a skull with the lower jaw, obtained by Mr. Thomas Bain from the Trias of Gough, in the Karoo district of South Africa. The postorbital part is broken away. The animal is mononarial; the alveolar border of the upper jaw is slightly sinuous, concave above the incisors, convex above the canines and molars, and then straight to beneath the orbits. The alveolar border of the mandible is concealed by the overlapping teeth of the upper jaw; its symphsis is deep, slanting backward, and destitute of any trace of suture; the length of the mandible is $3\frac{1}{4}$ inches, which was probably the length of the skull. The incisors are $\frac{5-5}{5-5}$, and the molars probably $\frac{5-5}{5-5}$ or $\frac{6-6}{6-6}$, all more or less laniariform. The length of the exserted crown of the upper canine is 12 millims.; the root of the left upper canine was found to be twice this length, extending upwards and backwards, slightly expanded, and then a little narrowed to the open end of the pulp-cavity. There is no trace of a successional canine; but the condition of the pulp-cavity and petrified pulp would seem to indicate renewal of the working part of the canine by continuous growth. The author infers that the animal was monophyodont. *Ælurosaurus* was said to be most nearly allied to *Lycosaurus*, but its incisor formula is Dasyurine.

With regard to the characters of the Theriodontia the author remarked that we may now add to those given in his 'Catalogue of South African Fossil Reptiles,' that the humerus is perforated by an entepicondylar foramen and the dentition is monophyodont.

3. "Additional Observations on the Superficial Geology of British Columbia and its Adjacent Regions." By G. M. Dawson, Esq., D.Sc., F.G.S.

This paper is in continuation of two already published in the Society's Journal (vol. xxxi. p. 603, and vol. xxxv. p. 89). In subsequent examinations of the southern part of the interior of British Columbia the author has been able to find traces of glaciation in a N. to S. direction as far as or even beyond the 49th parallel. Iron Mountain, for instance, 3500 feet above the neighbouring valleys, 5280 feet above the sea, has its summit strongly ice-worn in direction N. 29° W.-S. 29° E. Other remarkable instances are given which can hardly be explained by local glaciers; boulder-clay is spread over the entire district; terraces are cut in the rearranged material of this, bordering the river-valleys, and at greater elevations expanding over the higher parts of the plateau and mountains. At Mount It-ga-chuz they are 5270 feet above the sea. The author considers that the higher terraces can only be explained by a general flooding of the district. Some of the wide trough-like valleys of the plateau contain a silty material which the author regards as a glacial mud.

North of the 54th parallel and west of the Rocky Mountains similar evidence of glaciation is obtained; erratics are found in the Peace and Athabasca basins. The fjords of British Columbia are extremely glaciated, the marls being generally in conformity with the local features; terraces are scarce and at low levels. The Strait of Georgia was filled by a glacier which overrode the S.E. part of Vancouver's Island; evidence is given to show that this ice came from the neighbouring mountainous country. Queen Charlotte's Island shows evidence of local glaciation. Boulder-clays and stratified drifts are found, with occasional arctic shells.

The author considers that the most probable explanation of the phenomena of the whole region is to suppose the former existence of a great glacier mass resembling the inland ice of Greenland, and that the Glacial period was closed by a general submergence, during which the drifts were deposited and, at its close, the terraces cut.

Erratum.—In the March Number, page 138, line 15, of the Geol. Mag., for *stromatoporides* read *stomatoporides*.

CORRESPONDENCE.

FOREIGN PEBBLES OF BRITISH BEACHES.

Sir,—It is no doubt well known to Mr. Birds as well as many other observers, that the foreign pebbles, described by him[1] from the Brighton and St. Leonard Beaches, are not confined to the S.E. and S. coasts of England, they being indeed far more abundant in some places on the opposite coast of Britain.

Aberystwyth, in the centre of Cardigan Bay, is, like Brighton, celebrated for the "pebble" riches of its beach, which afford employment to a large number of lapidaries in their cutting and polishing. Now these "pebbles" are all of them foreign to the district, and many of them are not even British in origin. Flint agates and "onyx" are not uncommon, and jasper is abundant. Besides these there are large numbers of other interesting strangers, many of them igneous rocks, including granites and quartz-felsites in many varieties, both pink and grey; orthoclase-felsite, porphyrites, basalt, and serpentine, and volcanic agglomerate; also numerous sedimentary and metamorphic rocks.

So abundant are these foreign rocks that in some of the small Welsh bays they are decidedly more conspicuous than the local stones, and handfuls may be gathered in a square yard.

As to the origin of these pebbles I quite agree with Mr. Birds, that they are washed up from deposits now covered by the sea. I am not, however, able to see how these facts can determine for us the distribution of any vast ice-sheets such as Dr. Croll has described. To settle this question we must find whether the Boulder-clay was a true Till—a land-ice product, or only a marine Boulder-clay, stored with pebbles dropped from melting icebergs; and this cannot be settled by reference to the pebbles found on the beaches.

Now, in the case of the foreign stones of the Welsh shingles, none of them occur in the drifts of the neighbouring country, these drifts being entirely the products of local land-ice; but I have detected some of them in the drifts of the lowlands of Anglesea. These latter are, however, *marine* Boulder-clays—laminated deposits like the Norfolk Contorted Drift, and containing delicate marine shells in perfect preservation.

Therefore, I conclude that the foreign pebbles of the beaches are derived, not from any morainic formation produced by a vast ice-sheet, but from a Boulder-clay, formed as a marine deposit in the Irish Sea at a time when that sea was traversed by icebergs, brought hither by currents from the glaciers of Scotland, and Scandinavia.

The original homes of many of the rocks are unknown to me. There are many Scotch porphyrites, and a few rocks from the Lleyn peninsula. The flints and some basalts may have come from the North of Ireland.

W. Keeping.

The Museum, York.

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[1] See Geol. Mag. January, 1881, p. 47.

Zenaspis Salweyi, (Egerton, sp.)
(Cephalaspis Asterolepis.) from the Old Red Sandstone
Skerrid Vawr, near Abergavenny.

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No. V.—MAY, 1881.

ORIGINAL ARTICLES.

I.—NOTE ON A FINE HEAD-SHIELD OF *ZENASPIS* (*CEPHALASPIS*) *SALWEYI*, EGERTON SP. = *CEPHALASPIS ASTEROLEPIS*, HARLEY.

By the Editor.

(PLATE VI.)

On our Plate is depicted the head-shield of the well-known Old Red Sandstone fish, *Cephalaspis*, the genus first described by Agassiz in 1835, the species *C. Salweyi*, by Egerton in 1857, and still later as *C. asterolepis*, by Harley in 1859. The specimen was obtained by Mr. John Edward Lee, F.G.S., of Torquay, from the "Cornstones," Old Red Sandstone, Skerrid Vawr, near Abergavenny, and is drawn about one-third less than the natural size. "Two cornua were obtained by Dr. Mac Cullough from the same quarry at Abergavenny, furnishing the evidence of these parts which are wanting in Mr. Lee's specimen" (Lankester).

At page 53 of Professor Lankester's Monograph of Old Red Sandstone Fishes (Part I. Cephalaspidæ, Pal. Soc. Mon., 1870) is given a life-size outline woodcut of this specimen; but the breadth seems somewhat too wide in proportion to the length of the shield, which in Mr. Lee's specimen is more pointed in front.

Mr. Lankester observes (*op. cit.* p. 54), "Another specimen has been recently obtained for the British Museum which is better than that in the Geological Survey Museum drawn on pl. xii. fig. 2; or than Mr. Salwey's specimen" (see pl. xii. fig. 6).

These specimens seldom show the outer tuberculated layer, upon the character of which the specific differences between *C. Salweyi* and *C. asterolepis* have been founded. On some of these specimens a few of the tubercles are left here and there, but as a rule they merely show the beautiful stellate polygonal structure beneath the outer layer.

Prof. Lankester observes, "Sir Philip Egerton attached importance to the great breadth between the eyes, but the size of the individual and variations in pressure are liable to affect this character." He adds, "After some hesitation I have decided to associate *C. Salweyi* and *C. asterolepis* as one species, not being able, on careful examination, to find any character which should separate the large specimen described by Dr. Harley from Sir Philip Egerton's original *C. Salweyi*."

Concerning the genus, Prof. Lankester proposes (*op. cit.* p. 55) to place this large head-shield with others in the sub-genus *Zenaspis*, on the ground that with it have been found associated some remarkable scutes which are regular in size and hemispherical in outline. These scutes are symmetrical in outline, and were probably placed in the median line on the dorsal surface. They indicate an armature of body quite different from that of *C. Lyelli.* The flank-scales of individuals as large as Mr. J. E. Lee's specimen must have been of considerable size and strength.

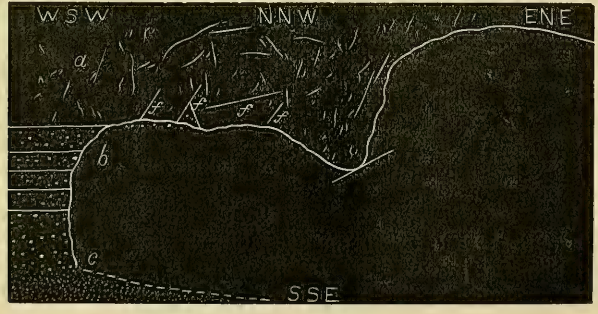
We are indebted to Mr. J. E. Lee for kindly permitting us to reproduce the plate of this fine fossil in the Geological Magazine.

II.—Evidence bearing upon the Position of the Twt Hill Conglomerate.

By R. D. Roberts, M.A., D.Sc. (Lond.), F.G.S., Clare College, Cambridge.

A DISCUSSION has more than once arisen, in the course of the last two years, respecting the true position of the quartz conglomerate exposed near Twt Hill, Carnarvon, which was first described by Prof. Bonney and Mr. Houghton in the Quarterly Journal of the Geological Society, vol. xxxv. p. 321. The typical quarry is situated on the S.E. side of the ridge, close underneath Twt Hill, and the exposure there shows the quartz conglomerate in juxtaposition to the granitoid rock that constitutes the axis of the ridge. The authors describe a passage between the granitoidite below and the conglomerate above, and state that the latter "passes up into a rock which has some resemblance to the bottom rock" (granitoidite). In the Geol. Mag. for March, 1880, p. 118, Dr. Callaway writes: "Messrs. Bonney and Houghton have detected at Twt Hill a passage between the granitoidite and a quartzose conglomerate with a S.E. dip. I have visited this section, and having examined the rock inch by inch, I can entirely confirm their identification."

Fig. 1. (Ground Plan of Twt Hill Quarry).



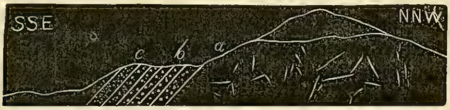
a. Granitoid Rock of Twt Hill. *c.* Sandstone.
b. Quartz Conglomerate. *f.* Small Faults.

To this view of the position of the quartz conglomerate as a part of the lowest Pre-Cambrian series, Prof. Hughes took exception; a careful study of the stratigraphical relations of the beds having led him to refer the conglomerate to the base of the Cambrian. Prof. Hughes's wide experience and acknowledged ability as a field geologist give great weight to his opinion on matters of stratigraphy, but certain difficulties have presented themselves, which cannot be lightly passed over. Apart from the alleged passage of the conglomerate into granitoidite, described by Prof. Bonney, Mr. Houghton and Dr. Callaway, there is the fact that the Cambrian conglomerate of the Bangor district and other parts of Carnarvonshire is largely made up of pebbles of felsite, while the Twt Hill conglomerate is composed chiefly of quartz pebbles and contains no felsite. These objections I believe I am in a position to meet.

A recent visit to certain sections in Anglesea, and a re-examination of the beds at Twt Hill, under specially favourable conditions, enables me to offer additional evidence strongly confirmatory of Prof. Hughes's view that the bed in question is the Cambrian conglomerate.

The following is the substance of notes taken during several visits to the Twt Hill quarry, and confirmed on the 6th of January, when I last visited the district. The quarry was on that occasion free from brambles and undergrowth, which in the summer somewhat obscured the section, and the relations of the beds were clearly shown. On the N.N.W. side of the quarry—western corner—the granitoid rock is succeeded by the conglomerate, which in some parts is fine, in others coarse. The pebbles are mostly quartz; very rarely one of dark quartzite or schist may be found. They vary from the size of a grain of wheat to that of a pigeon's egg. The quartz pebbles frequently exhibit a glazed appearance, and the matrix contains crystals of iron pyrites disseminated through it. The conglomerate stretches E.N.E. and dips S.S.E. at an angle of about 50°. Succeeding it and bounding the southern rim of the quarry is a bed of sandstone, which may also be detected a few feet beyond the quarry. That this rock is not similar to the bottom rock (granitoidite) is clear from the character of the bed, but to remove all shadow of doubt, I have procured a section of the rock for the microscope, and the result completely bears out the stratigraphical inference. Standing in the quarry, and facing towards the N.N.W., the conglomerate is seen dipping down the rock-face towards the spectator, clinging as it were in patches to the underlying granitoidite so as to give an appearance of beds dipping to the S.W. It is much decomposed by the weather, and the pebbles may with ease be picked out. The rocks are much traversed by fissures, which frequently show slickensided surfaces indicating movement, and in

FIG. 2. Section in Twt Hill Quarry from *a* to *c* (Ground Plan).



many instances small shifts may be detected by carefully tracing bands of rock across the fissures. Many of the cases of apparent passage proved on close examination to be the result of small faults bringing into intimate juxtaposition the conglomerate and granitoidite. The decomposition at the junctions in parts also rendered it difficult at first sight to make out the relations of the rocks, but after several hours' careful examination of the section at different times, I entertain no doubt that the conglomerate is quite distinct from the granitoidite and belongs to a later period.

At the eastern end of the quarry the typical granitoid rock is quarried, and it presents considerable variation in appearance in different parts of the quarry; it is traversed at one spot by bands of white quartz, which might well have furnished the materials of the pebbles in the conglomerate. More than once in a N.E. direction these beds are again exposed, notably in a quarry between Tygwyn and Ysyuborwen. There the conglomerate is seen somewhat coarser in character than in the Twt Hill quarry, alternating with beds of grit and sandstone and showing the same strike and dip. Pebbles of jasper, quartzite and schist are rather more numerous here and the character of the bed is well shown.

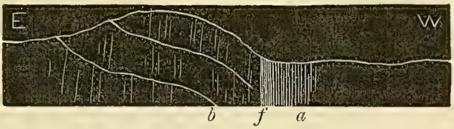
The evidence seems therefore clearly against the view that the conglomerate with its associated grits and sandstones is a part of the Pre-Cambrian granitoid series. On the other hand nothing hitherto said points conclusively to the base of the Cambrian as the true position of these beds. To the complete and final settlement of the matter it is necessary that either undoubted fossiliferous Cambrian beds should be traced down into the deposits in question, or better still that fossils should be found in the sandstones themselves overlying the conglomerate. Both these demands can, I believe, be satisfied. The evidence has been obtained in another district where the exposures are more numerous and the stratigraphical relations more readily made out than in Carnarvonshire. On two occasions last year I had the advantage of being conducted by Prof. Hughes over parts of Anglesea, where we found beds not distinguishable from those exposed at Twt Hill. I shall refer to three sections.

1. On the shore in Dulas Bay, a few miles to the S.E. of Amlwch, black slates occur, in which we had the good fortune to discover Graptolites. These will be described in a forthcoming paper by Prof. Hughes. We traced the beds inland, and finally made a traverse across the strike with the object of finding if possible the basement conglomerate. The black slates we traced passing down into brown sandstones, and these into a conglomerate identical in petrological character with the Twt Hill conglomerate. It is well shown in a quarry at Penlon, about two miles due west of Traeth Dulas. The appearance of the quarry is singularly like that at Twt Hill. The conglomerate, made up of quartz pebbles, rests on granitoid rock and passes up into brown sandstones.

2. Dr. Callaway states in the Geological Magazine, for March, 1880, p. 118, that near Nebo, two miles S.E. of Amlwch, he discovered in two quarries a quartzose conglomerate, "lithologically

perfectly indistinguishable from the Twt Hill rock," which he holds to be unconformably overlaid by black Cambrian shales, and thus according to his view proving the Pre-Cambrian age of the grit. In company with Prof. Hughes, I visited these quarries towards the close of last year. We found the conglomerate and grit and the black shales against them, but saw no unconformability. The black shales crushed and broken at the junction are faulted against the conglomerate in the manner shown in Fig. 3.

Fig. 3. Section in Quarry ¼ E.S.E. of Nebo, Amlwch.



a. Black slate. *b.* Jointed and veined grit conglomerate in parts. *f.* Fault.

In the larger quarry the grit and conglomerate are much traversed by joints running in the same direction as the fault, which joints might easily be mistaken for lines of bedding, and the shale would then appear to be resting on the "upturned edges" of the conglomerate. These sections, therefore, do not bear out Dr. Callaway's interpretation.

3. About a mile and a quarter from Llanerchymedd, on the S.W. road, not far from Bryngwallen, the granitoid series is exposed in a quarry on the S. side of the road. On the opposite side, in a field, about 50 yards from the road, another quarry has been opened in beds of grit and conglomerate. The latter is composed of pebbles of quartz, imbedded in a matrix containing crystals of pyrites, and resembles in all respects the conglomerates of Penlon, Nebo, and Twt Hill. It passes up, as does the conglomerate in the other sections, into grit and sandstone. The sandstone only a few feet from the conglomerate includes a fossiliferous band containing *Orthides.* This fixes the position of the sandstones and with them the quartz conglomerate into which they pass. Even if it be denied that this conglomerate and the Twt Hill conglomerate are identical in spite of their singular resemblance to one another, this discovery removes the only really strong *a priori* argument against referring the Twt Hill bed to the Cambrian series, viz. the absence of felsite pebbles. The Bryngwallen conglomerate, which passes up into fossiliferous sandstone, is composed of pebbles of quartz, imbedded in a felspathic matrix and is not distinguishable in the field from the Twt Hill conglomerate.

III.—ÆOLIAN SANDSTONE.

By T. Mellard Reade, C.E., F.G.S.

As bearing upon the subject of Mr. J. Arthur Phillips's interesting and valuable paper in the last number of the Quarterly Journal of the Geological Society, entitled, "On the Constitution and History of Grits and Sandstones," a description of a cliff section of blown sand now to be seen on the coast at Crosby may not be without value. The section in question, which attracted the attention of a local geologist, Mr. William Semmons, and myself, is at a point on the coast where the sea is encroaching upon the sand-dunes, and washing them away at the base leaves the face almost vertical. The resemblance of the sand to rock is most striking, presenting all those peculiarities of cross-bedding and lines of erosion we are familiar with in some of the Triassic sandstones of the neighbourhood. During the last twelve years, in walks along the shore, I have often observed the laminations of the blown sand disclosed by denudation, but never so strikingly as in the present case. The beds not only display delicate laminations, but stand out in ribs and cornices, simulating Gothic mouldings in profile. On trying how so loose a material as blown sand could retain these projecting forms, I was surprised to find the projections comparatively hard and solid. On breaking a piece off, the reason became apparent; for instead of the usually dry incoherent grains of sand, below the surface-skin the sand was quite damp. A very little addition of siliceous or calcareous cement would turn the mass into rock.

The explanation is obvious. The late very wet winter has allowed the entire mass of the sand-hills to become saturated with moisture, and the water adhering to the grains gives them cohesion. The sea saps the base, and the wind acting upon the vertical face of the sand so produced, developes the latent form of rock-structure contained within it.

The microscope shows that the grains are much rounded, but in this case not solely by wind action. There is no doubt that the grains of sand, before being finally built up into sand-dunes, are washed over the shore again and again. They are blown over the shore at neaps in strong winds, and as often devoured again by the sea. We are also unaware of the initial shape of the grains, as I have no doubt they are primarily derived from the Triassic rocks, and secondarily in part from the drift. The rounding may therefore be the result of ages of abrasion. What wonder then that Mr. Phillips finds that five miles of travel down stream did little or nothing towards rounding grains of siliceous sand!

Outside the estuary of the Mersey are great sand-banks, such as the Burbo Bank, continually shifting, yet preserving a certain permanence of form. Admiral Spratt, F.R.S., the Acting Conservator of the Mersey, in his report for 1879, considers that the sand is continually travelling in great circles, in directions he particularly describes, round these banks. Here then is a great grinding mill for rounding the grains, as doubtless many of them have been on the banks before getting washed on to the shore.

IV.—The Mammoth in Europe.[1]

By Henry H. Howorth, F.S.A.

HAVING considered the conditions under which the Mammoth lived in Siberia, we now propose to turn to the parallel problem in Europe, and to show that the mode of life was practically

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[1] Continued from the Geological Magazine, 1880, Decade II. Vol. VII. p. 561.

the same in both areas, and that the problem which has to be solved is virtually the same in both.

It is true that in Siberia we find carcases of the Mammoth remaining with their flesh intact, a circumstance which is not known in Europe; but this is entirely due to the fact that the ground in no part of Europe which has been sufficiently explored is frozen all the year round, so as to enable the soft parts of the Mammoth to be preserved. The country east of the White Sea, and between it and the great gulf of the Obi, may very possibly satisfy this condition; but it is virtually a *terra incognita* in regard to its geology, and it is only recently that its superficial aspects have been examined with any attention. Elsewhere in Europe, the ground in summer is not permanently frozen, and it therefore cannot preserve what is so subject to rapid decay as the flesh of animals. But, although we have not the flesh itself, we have what is equivalent to it for our purpose, namely, the preservation of skeletons, with their various bones remaining in position, and under circumstances which make it clear that when buried they were clothed with flesh, just as the bodies in Northern Siberia were, and that it is only an absence of the requisite cold which has interfered with their complete preservation. We find in Europe what we find in *Central* Siberia. There also the cold is not sufficient, and in consequence we have in that area no bodies with their flesh, but only skeletons. Such an one was that found by Messerschmidt on the river Tom, south of Tomsk, and referred to by Strahlenberg, and another referred to by the same author, found near Lake Tzana, between Tara and Tomskoi, which, from his account, still retained its articulations (Strahlenberg, p. 404).

To most of us it is difficult to realize how purely artificial the terms Europe and Asia are. How they correspond to nothing, either in historical or physical geography. The Ural mountains form no frontier that has been of the slightest interest in history, while as a physical formation they are of even less importance. Their moderate height and frequent passes have formed no barriers, either botanical or zoological, and the country with its living *facies* is practically the same on both sides of the chain. It is not a mere figure of speech by which my friend Mr. Seebohm, in describing his recent journey to the Petschora, calls that area "Siberia in Europe." Siberia, as a physical province, really begins with the great Polish plain, and includes the monotonous levels of European Russia. This being so, it is not remarkable that we should find in European Russia, skeletons of Mammoths occurring under similar conditions to those of Siberia, and equivalent, as we have seen, if the conditions of climate were the same, to the occurrence of bodies with their flesh intact. The most important of these, and the one of whose discovery we have the greatest details, was found about the year 1846, near Moscow. The skeleton was found at Troitzkoe, not far from Khoroschowo, in the bed of a dried-up stream, which must once have fallen into the river Moskwa. It was described by Prof. Charles Rouillier, the then Secretary of the Imperial Society of

Naturalists. The skeleton was standing *vertically*, the fore-feet having sunk lower than the hind ones, and Brandt says that it must have sunk down in soft mud. His remaining remarks are so exactly what I would urge, that I prefer to quote them in the original as the words of a very skilled palæontologist. He says: "Würde das Moskauer Governement damals einen ewig gefroreren Boden besessen haben und noch bis auf heute besitzen ähnlich wie der Norden Siberiens, so würde das fragliche Mammuth wohl als ganzes Cadaver zum Vorschein gekommen sein."—Bulletin de la Soc. Imp. des Natur. de Moscou, vol. xi. part ii. p. 250.

About 1826, according to a communication made by Pander to Brandt, there was found on the banks of a river near Petersburgh the skeleton of a Mammoth, which was also in an upright position (Bericht ueber die Verhandl. Berliner Acad., 1846, pp. 225, 226). This skeleton may be paired with another discovered in 1775 at Swijatosski, 17 versts from St. Petersburgh, and which is mentioned by Buffon (see De Blainville, Osteographie, p. 108).

Tilesius mentions that a complete Mammoth's skeleton was found at Struchof in the government of Kazan.

In 1821, as appears from a letter written to Cuvier from St. Petersburgh, there were found, in the government of Woronej, two entire skeletons, whose tusks, although broken, were many feet long. It was argued these were the remains of elephants brought to Russia during the invasion of the Tartar, Mamai (Cuvier, Ossemens Fossiles, vol. ii. p. 164).

Travelling to another corner of European Russia, Von Nordmann mentions the discovery of a complete skeleton 40 versts from Odessa, seven fathoms under the ground, of which he secured a portion of a hip bone and two tarsi (Palæontologie Südrusslands, p. 273).

In Western Russia, De Blainville reports the fishing up of the molar of a young animal *with other bones of the skeleton* from the river Uscha, near the Obrinka, not far from Grodno (*op. cit.* p. 112).

Hagenius (Beitrage zur kunde Preussens, vol. i. p. 56) reports how the illustrious "Castellanus Sremensi'" had informed him that a whole skeleton of an elephant was found at the town of Gruczno on the Vistula, which was broken to pieces by the peasants, but he secured part of a tusk (see Baer, de Fossilibus Mammalium reliquis, p. 13).

In Germany several cases are known. Of these the most famous, perhaps, were the two skeletons found at Tonna, in the province of Gotha. One of them was discovered in 1696, and a femur with the head of another, a humerus, some vertebræ and ribs, together with the skull, four molars, and two tusks were recovered. Tentzel described the remains in the 19th volume of the Philosophical Transactions, and proved, by an elaborate examination, against the views of the doctors of Gotha, that these bones were not *lusus naturæ*, but the remains of an elephant. The perfection of the skeleton may be judged from Tentzel's words: "Equidem nihil dubitare attinet, quin omnia reperta sunt ad absolvendum

Elephanti sceleton necessaria" (see Tentzel, Epist. de Sceleto Eleph., Phil. Trans. vol. xix.; Cuvier, Ossemens Fossiles, 4th ed. vol. ii. pp. 81—84).

A second skeleton described by Cuvier was discovered 50 feet from the former one. This was in a cramped and curved position, occupying a space 20 feet in length, the hind-feet being near the tusks. The latter had fallen out of the alveoles and were crossed (Cuvier, *op. cit.* p. 85).

From the valley of the Oder we have the record in Volkmann's Silesia subterranea of the discovery of the bones of a giant in digging the foundation of a church at Leignitz. These bones, like similar bones from other sites, were probably those of a Mammoth.

Brockman (Epist. itin. p. 30) mentions the finding of a skeleton of a Mammoth at Tiede, in the valley of the Ocker, a short distance from Wolfenbuttel, of which Leibnitz figured a molar tooth. Another skeleton was found at Osterode, at the foot of the Hartz, by Dr. Koenig. These finds are both mentioned by De Blainville, who adds that skeletons have also been found in the valley of the Unstrut (*op. cit.* p. 119). Schlotheim mentions an entire skeleton of a Rhinoceros found in 1784 at Ballenstedt, which was broken by the workmen (Cuvier, *op. cit.* p. 93).

South Germany, with its mountainous contour, was not well adapted to the habits of the great pachyderms, and, like the mountainous district of Siberia, is not so fruitful in Mammoths' remains as the more level country. We *à fortiori*, therefore, do not meet with so many cases of skeletons or parts of skeletons found more or less intact. In 1605 a tusk with some Elephants' bones were found near Halle, in Suabia; the tusk still hangs in the church of Halle (Cuvier, *op. cit.* p. 95). Schlotheim, in his Connaissance des Petrifactions, p. 5, speaks of a skeleton found near Passau, at the confluence of the Inn and Danube (see Cuvier, *op. cit.* p. 97). In 1807 many portions of an elephant's skeleton well preserved were found at Neustaedt or Vag Ugheli, on the Vag in Hungary (id. pp. 98, 99), A vertebra, teeth and ribs, forming no doubt portions of a similar skeleton, were found in Syrmia between the Save and the river of Baczinco (id. p. 99).

When we travel into the Rhine-lands, we find ourselves in a district rich in remains of the Mammoth, and several skeletons are recorded as having been found there.

In 1577 the skeleton of a so-called giant was found at Lucerne under an oak-tree which was overturned by a storm. Felix Plater, professor of medicine at Basle, described the bones as the remains of a giant, and designed a human skeleton nineteen feet high, to match the bones, of which a picture is still preserved in the Jesuits' College at Lucerne. On it is an inscription giving a list of the bones. These bones were seen by Blumenbach, and recognized as those of an elephant (Cuv. *op. cit.* pp. 72, 73).

In the year 7 of the first Republic, an almost complete skeleton was found at Vendenheim, a short distance from Strasburgh, in an outlier of the Vosges. A few years earlier, another skeleton was found at Eppig, eight leagues below Strasburgh, also in the Vosges (id. p. 127; De Blainville, p. 74). An entire skeleton with two tusks is reported by De Blainville as having been found under vegetable soil close to the walls of Stuttgart, on the Neckar, in Wurtemberg. Merk describes the various bones of an elephant found together at Erfelden in Darmstadt.

But it is when we reach the alluvial flats of the Low Countries that we find, as we should expect, the most notable examples of what we are describing. Lulof speaks of a tooth and many bones of an elephant found in the valley of the Yssel, near Zutphen (Cuv. pp. 79, 80).

In 1643 an entire skeleton was disinterred at Bruges by Otho Sperling, of which a femur still remains in the Danish Collection (Cuv. pp. 68, 69). Two entire skeletons with molar teeth and tusks were found in digging the Canal from Brussels to Rupemonde, near Vilvorden (De Blainville, p. 130). In 1742 a skeleton was found in marl, half a league from Ostend (id.).

It was in February, 1860, however, that the most important discovery of this kind took place in Belgium, namely, at Lierre, between Antwerp and Malines, where the bones of a Mammoth were discovered, and secured. These remains were described in the Bulletin of the Belgian Academy (2nd ser. vol. ix. pp. 405 and 436). The magnificent skeleton possessed by the Royal Museum at Brussels, and which gives to that collection such importance in the eyes of palæontologists, proves how rich this deposit was.

In Britain the remains of the Mammoth have, for the most part, been found detached and separate; but this has not been universally so, the great skeleton, thirty feet long, found at Harwich in a decayed condition, being a notable instance to the contrary.

In France we have several examples to quote. It must be remembered that until comparatively recently, when skeletons of a large size, and which were in all probability those of Mammoths, were discovered, they were attributed to giants, and that from early times the discoveries of such giants are not infrequently reported; in fact, a very large series of such examples was collected by Cuvier. A typical specimen is the one mentioned by Phlegon, of Tralles, who described a body of an immense size exposed by an earthquake near the Cimmerian Bosphorus, whose bones were thrown into the Maeotis.

One of the most interesting of these so-called giants was discovered at Langon, near Romans, in Lower Dauphiny, in France, in the reign of Louis XIII., which led to a great dispute, in which it was argued fiercely by some learned doctors that the bones were those of Teutoboccus, the king of the Teutons and Cimbri, defeated by Marius in 150 B.C. They were opposed by Riolan, who argued that they belonged to an Elephant. These bones naturally became precious, and were preserved by the proprietors of Langon, and through the influence of De Blainville they were eventually deposited in the Paris Museum, and shown to be those of the

Mammoth (see Gervais, Zoologie et Paleontologie Française, pp. 33–34).

A skeleton of a Mammoth was found on the right bank of the Lower Rhone near Lavoulte in the department of Ardeche. It was almost entire, and was described by Soulaire (Hist. Nat. de la France, vol. ii. p. 198). Another almost entire skeleton, with the remains of other animals, is described in the Bull. of the Geol. Soc. of France, (2nd ser. vol. xxii. p. 414), as having been found at Trosly Loire, west of Coucy le Chateau, in a cavity in the chalk.

Cuvier (*op. cit.* vol. ii. p. 155) mentions the finding in August, 1824, of portions of the skeleton of an elephant on a hill separating the Rhone and Saone.

Lastly, we may quote in his own words an interesting passage from a communication made by M. Baillon, correspondent of the Natural History Museum; speaking of his discoveries at Menchecourt, he says of some of the bones: "Ils y sont entiers, sans brisure ni frottement, et il est probable *qu'ils etaient encore articulés quand ils ont été recouverts.* J'y ai trouvé un membre posterieur de Rhinoceros dont les os étaient encore dans leur situation relative ordinaire. Ils ont du être joints par des ligaments et même entourés de muscles à l'époque de leur enfouissement. Le squelette entier du même animal gisait à peu de distance. J'ai remarqué que toutes les fois qu'on rencontrait des ossements disposés de cette manière et pour ainsi dire, encore articulés on trouvait egalement que le sable formait sur un de leurs cotes un agglomeration très dure" (Bull. Geol. Soc. of France, 2nd ser. vol. xxi. p. 40). The agglomeration of hard sand mentioned in the concluding sentence seems to point to the carcase having decayed close by and thus given a more or less cohesive texture to the inclosing material.

I do not propose to travel into Italy or Spain, where our problem becomes complicated by our entering another zoological province, which in fact we partially do in France and England, where, as Sir Charles Lyell and Mr. Dawkins long ago pointed out, we are on the verge where two such provinces more or less overlap, and we consequently meet with forms—*Elephas antiquus, Rhinoceros leptorhinus,* and *Hippopotamus major*—which are not found further to the northeast. We do not profess in this paper to give a complete list of the skeletons of the great pachyderms that have occurred in Europe. Ours has necessarily been but a casual gleaning; but the cases cited will suffice to show that such skeletons have been found in all parts of the European continent, from the Urals to the Western limits of the occurrence of Mammoth remains, and have not been so infrequent nor so limited as to locality as some have supposed. In addition to the skeletons of the pachyderms, we might have quoted a catena of examples of the occurrence of skeletons more or less complete of the lesser mammals, which prove the same facts, *e.g.* the cases of the numerous entire skeletons of the Irish Elk found in Ireland and the Isle of Man, and of the perfect skeletons of Marmots found at Aix-la-Chapelle, and Fisherton in Somersetshire. Cuvier reports the discovery of a fossil skeleton of a horse at Berg, near

Canstadt (O. F. p. 94), of skeletons of the Red-deer at Wiedikow, Flurlingen, and Oeningen, of the *Bos primigenius*, in Hanover, and similar cases might of course be quoted at considerable length. The museum at Lund in Sweden alone supplying excellent materials.

These examples will, however, suffice to show how very general the preservation of intact skeletons corresponding under other climatic conditions to the bodies preserved with their flesh intact in Siberia is in Europe.

As in Siberia, the great majority of the remains of Mammoths no doubt consist of scattered bones, and of these such a number has been discovered that it would occupy a folio to describe them. I will here only call attention to two or three examples, which seem to point to some generalizations on the limits of distribution of the Mammoth in Europe having to be reconsidered.

It was long ago observed that the borders of the Baltic are much less fertile in Mammoth remains than those of the North Sea, and they do not in fact seem to have occurred in some large districts bordering upon it. At all events they are not named by Eichwald as occurring in Livonia, nor are they named from Ingria or Lithuania. It is therefore natural that when we get further north than this it should be concluded that they do not occur at all. Thus it has been asserted that the Mammoth has not occurred in Scandinavia.

Scandinavia and Finland have in some respects virtually the same physical features. Now Cuvier expressly tells us that he received a lower molar tooth of a Mammoth, which had been found in Ostro-Bothnia in Finland, from M. Quesnel, who was in charge of the Natural History Collection at Stockholm. He refers further to some gigantic bones disinterred at Falkenberg in the province of Halland in Sweden in 1733 by M. Daebeln, and of which he gave figures in the Act. Acad. Nat. Cur. 5, tab. 5. Cuvier says that these figures apparently represent the first rib and carpal bone of an elephant.

In Denmark remains of the Mammoth, although infrequent, have certainly occurred. A tooth was exhibited at the Congress of Anthropology at Copenhagen in 1869, which was found near Odense, and M. Valdemar Schmidt, who exhibited it, said a small number of other teeth found in different parts of Denmark are preserved in the Zoological Museum attached to the University (Comptes Rendu, p. 31).

A more curious locality is Iceland, which is reported in a memoir by Thomas Bartholin, in an early number of the Copenhagen Academy, where we read of a molar tooth sent by Resenius from Iceland, and given by him to the University of Copenhagen. It is described as petrified like flint, and we are told that Sir Hans Sloane had a similar tooth whose origin was unknown (see Cuvier, O. F. p. 117). It ought to be added that De Blainville has suggested that these teeth perhaps belonged to the Mastodon, whose teeth often have this flinty texture. It is quite clear that the physical configuration of both Scandinavia and Finland, as in the cases of the North of Scotland and of Brittany, would make these areas uncongenial to the Mammoth. Just as the thick forests which then probably covered Ireland, and were the favourite retreats of the Megaceros, were also uncongenial to it, so that its remains are very rare there; but it is important to remember that the reasons for its rarity in these areas were topographical and not climatic ones.

We saw that one of the curious features of the distribution of the extinct mammals in the surface deposits of Siberia was their occurrence in immense hecatombs, in which the bones of various animals are mixed together pell-mell. The very same thing occurs also in Europe. Your readers are familiar enough with the famous deposit found at Canstadt, in Wurtemberg, in 1700. Reisel says that more than sixty tusks from this deposit were sent to the Pharmacy of the Court, to be used as fossil Unicorns' bones. In this great deposit the bones and teeth lay in a confused mass in a deposit of yellow brickearth, containing fresh-water shells. Many of the remains from this deposit are now at Stuttgardt, and include Elephant, Rhinoceros, Horse, Deer, Oxen, and small Carnivora. In 1816 another great depôt or cache of the same kind was discovered at Seelberg, about 600 paces from Canstadt, on the other side of the Neckar, and excavations were systematically carried on. In twenty-four hours, twenty-one teeth and parts of teeth, and many bones, were found; on the second day, thirteen tusks, placed close together, with many molars. The greater part of the tusks from this site, although they had lost their alveolar portion and their points, were eight feet long, the molars were from two inches to a foot in length, and some were found still adhering to the jawbones. The tusks were much curved. As in 1700, the Elephants' remains were found mixed with those of the Rhinoceros, Horse, Stag, Bear, etc. (Cuvier, O. F. pp. 86–92).

In 1817 M. Berger, of Brunswick, found an immense depôt of bones and tusks of Elephants mixed with the bones of Rhinoceros, Horses, Cattle, and Deer, in the district of Lindenberg, on the Ocker. Eleven tusks and thirty molars were clearly distinguished as those of the Mammoth (id. pp. 101–102).

In the reign of Peter the Great an immense mass of Elephants' bones, with those of other animals, were found at Kostynsk, near Voronej, on the Don, in Russia. They were attributed by the Tzar to the campaigns of Alexander the Great (*id.* p. 122).

(To be continued in our next Number.)

V.—On The Glaciation of the Shetlands.[1]

By David Milne Home, F.R.S.E., F.G.S.

In the February Number of the Geological Magazine, there is an article by Messrs. B. N. Peach and J. Horne, answering the doubts expressed by me regarding the soundness of their views on this subject.

These doubts, after a perusal of their interesting paper in the Quarterly Journal of the London Geological Society for November,

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[1] Being the reply of Mr. Milne Home to the answers by Messrs. B. N. Peach and J. Horne, of the Scotch Geological Survey, to his criticism of their paper on the Glaciation of the Shetlands.

1879 (of which paper they had courteously sent to me a copy), I thought it allowable, in my annual Address as President of the Edinburgh Geological Society, to express, as bearing on an important question of Scotch Geology.

Messrs. Peach and Horne, not acquiescing in my criticisms, have, in the article to which I refer, as they were entitled to do, given explanations on some of the points noticed by me; and I now desire to say, how far I am satisfied, or not satisfied, with their explanations.

1. On one point I am of course satisfied. I had demurred to the astounding declaration in their paper, "that the land-ice which glaciated Scotland could only have come from Scandinavia" (page 809).

These gentlemen explain that, "owing to an unfortunate printer's error, the word *Scotland* in the foregoing sentence has been substituted for *Shetland*"—"an error (they add) self-evident to any ordinary reader after a careful perusal of the context."

I at once accept the explanation; but when it is said that to any ordinary reader the error was self-evident, I must be allowed to reply that the context did not, and even now does not, manifest the mis-print to me.

2. The more important question is, whether there be sufficient evidence in the paper to support the theory originally started by Dr. Croll, and warmly advocated by his colleagues in the Survey, that the Shetlands were "*over-ridden*" and "*smothered*" by a *Scandinavian* Ice-sheet.

(1). They state that the arrival, impact, and progress of this Ice-sheet on the Islands, is indicated by numerous *striæ* on the rocks. Along the whole Eastern Seaboard of the Islands, the striæ show, it is said, a movement of the ice from N.N.E. or N.E.; but that, after "impinging on the Islands," and "reaching the crest of the Mainland, it was *deflected* by the opposing high ground," "and as it left the Mainland, it *veered round* towards the N.W. and N.N.W." (page 796). This remarkable phenomenon is again described thus:—"The Ice-sheet abutted on the Eastern Seaboard of Shetland with a S.S.W. and S.W. trend; and after reaching the crest of the Mainland, it *swung round* to the N.N.W. and N.W." (page 790), in order, as is afterwards explained, to "*follow* the *path* of *least resistance*" (page 809).

Among the places on the Eastern Seaboard, where the direction of the striæ is given, there is the Island of *Unst*, at the north end of the group. The exact direction of the striæ there is thus stated:—"Along the Eastern Seaboard of *Unst*, the direction of the ice-markings varies from W. to W. 20° S. From Norwick to Haroldswick, numerous striæ occur on the cliff-heads, running W. to W. 20° S.; some of which were found on the top of a cliff 500 feet high; while in the southern parts of the island the average trend is W. 30° S."

I stated in my Address that considerable doubt must be felt as to the correctness of these statements, on account of the discordant testimony of Mr. Peach, *senior*, who, at the special request of

Sir Roderick Murchison, examined the Shetlands as regarded their glaciation, and had made a special report thereon to the British Association in 1864. Now, nothing can be more distinct and decided than Mr. Peach's observations on the striations and corresponding transport of drift in Unst. As I did not in my Address deem it necessary to quote all that Mr. Peach stated, I hope I may be allowed to do so now. He says that, "in Haroldswick Bay (on the East Coast of *Unst*), he found a thick deposit of clay, in which polished and striated stones were plentiful. Part of the deposit had recently slipped off the rock, and here *the markings were so splendidly shown*, as if the grating masses had passed over it only a few days before. *The direction of the striæ was nearly W.N.W. and E.S.E.*" Mr. Peach then goes on to say, that he "ascended Heog Hill, which sloped up from the spot just mentioned, to the height of 500 feet," and there, as before, he found "*the W.N.W. end, vertical and polished to the depth of at least* 150 *feet.*" "The hills to the north of Heog Hill slope down towards it; and down these, no doubt, the crushing agents came. The *vertical* and *storm* side of Heog Hill had evidently *resisted* a portion of the destroyer, and turned the greater part on its *western* flank, and thus the main body passed down the valley towards Haroldswick, as evinced by the greater destruction there than on the *eastern* side."

This statement by Mr. Peach, *senior*, these gentlemen seem to have felt to be so serious a contradiction of their statements, that, after seeing my reference to it, they applied to Mr. Peach, and obtained from him a letter, dated November, 1880, which they embody in their answers, and which, they say, "enables us to *account for* the *discordance* between the recorded observations of Mr. C. W. Peach and ourselves." I confess I cannot see how this letter accounts for the discordance. On the contrary, it only proves the discordance, and shows it to be unaccountable. Mr. Peach, in his letter, says, "I send you a copy of my paper on Shetland, in which I stated that the striæ on the Heog Hill, Unst, run nearly W.N.W. and E.S.E. In the closing sentence of that paper, I also stated that my bearings are by compass, no allowance having been made for variation. Since I wrote that paper, having seen much more of the glaciation of Scotland, and thought more about it, I have seen cause to alter my opinion as to the direction of the drift . . . . I now feel quite satisfied that, although I noticed the bearings of the *striæ* right, I was wrong as to the direction of the *drift.*"

Messrs. Peach and Horne, commenting on this letter, observe, that when allowance is made for magnetic variation, Mr. Peach's bearings would be, not W.N.W., as stated by him, but "nearly E. and W., as noted by us." This remark I don't understand; for, as the compass in Shetland, in the year 1864, stood 24° to the west of *true* north, Mr. Peach's observation, by true bearing, indicate N.W., and not due E. and W.

But the more material point is this—Messrs. Horne and Peach, judging by the striæ in Unst, stated that the Ice-movement was from the *eastward.* Mr. Peach, *senior*, on the other hand, saw that it was from the *westward*, as indicated not only by what he calls the *splendid striæ* on the rocks at Haroldswick, but by observing that the "*storm*" side of Heog Hill was on its W.N.W. side, and was polished on that side, for no less than 150 feet from its top.

True, Mr. Peach says he has now altered his opinion as to the direction of the *drift* in Shetland. Had this alteration of opinion arisen from another and a recent examination by Mr. Peach, *senior*, of the locality, it would have been conclusive. But Mr. Peach explains that this alteration has arisen from his having, since making his Report to Sir Roderick Murchison and the British Association in 1864, "*seen* much more of the glaciation of *Scotland*, and *thought* more about it." Now, his seeing and thinking more of the glaciation of Scotland since he made that report, cannot alter the *facts which* he allows he saw in Shetland; and which incontestably prove the Ice-movement there to have been from the north-westward.

Unst, however, is not the only island where a discordance exists between Mr. Peach's observations of the striæ and those of Messrs. Peach and Horne. Mr. Peach, *senior*, examined *Whalsay*, a small island situated a few miles to the east of the Mainland; and therefore one of the first spots which would be passed over by the alleged Scandinavian Ice-sheet. Messrs. Peach and Horne say of this island, that on both sides of it, there are striations showing an average movement towards S. 28° W. On the other hand, Mr. Peach, *senior*, says that, not satisfied with taking the direction of the striæ at places where he found the rocks exposed, he removed the drifted clay and stones, in order to obtain a fresh surface; and the scratches at all the places (he says) "run nearly east and west,"—which, by true bearings, would be E.S.E. and W.N.W. Here, again, is discordance between Mr. Peach, *senior*, and the authors of the paper.

Going farther south, viz. to *Lerwick*, *Bressay Island*, and the long peninsular tongue of low-lying land, called *Sandwich and Coningsburgh*, we find striæ marked on the map attached to the paper, showing Ice-movements from the N.W. These discordant markings Messrs. Peach and Horne ascribe to local glaciers; of which glaciers, however, as it seems to me, there is not the slightest evidence, or even possibility, considering the want of high hills or valleys to have formed them.

Therefore, as regards the striæ on the *Eastern* Seaboard of the Shetlands, it distinctly appears that, so far from confirming the theory of an invasion of an Ice-sheet from the N.E., most of these striæ are at right angles to that direction.

If next we turn to the *Western* Seaboard of the Islands, do we find any proof of the extraordinary statement that the Ice-sheet, when it impinged on the Islands, "*veered*" or "*swung* round" to a N.W. direction? Messrs. Peach and Horne suggest a presumption in favour of this evolution, by saying, that *thereby* the Ice-sheet *would* "follow the *path of least resistance*." But how can this be? If the Ice-sheet came from Scandinavia, it would be about 400 miles long. If it enveloped and overtopped "both the Orkneys and the Shetlands" (as Dr. Croll supposed, p. 779), it must have had a breadth of at least

200 miles; and its "minimum thickness" is alleged (p. 809) to have been 6000 feet. Now this huge mass, it is said, when it impinged on the Shetlands, and reached the crest of the Mainland, "was deflected by the opposing high ground," and in order to "follow the path of least resistance," swung round to the N.W. The Shetlands form a group whose axis is N. by E. and S. by W. If it be possible to imagine, that a body of ice of the above gigantic dimensions, bearing down on these Islands from the N.E., could have its course changed by impinging on them, so as to seek the path of least resistance, its progress would have been along the Eastern Seaboard of the Islands in a direction S. by W., and not across the backbone of the Islands in a N.W. direction.

No presumption therefore arises in favour of a N.W. movement of the Ice-sheet in respect of the mathematical reason assigned. But perhaps the observed facts support this N.W. theory? The very reverse. In the majority of cases where striæ were observed and recorded, Messrs. Peach and Horne have honestly confessed in their text and their map that the striæ do not show a N.W. direction, and they have taxed their ingenuity to explain the discordance, without having to give up Dr. Croll's Ice-sheet.

For example, in North Mavine, one of the Westerly Islands, they allow, that there are two sets of striæ, "one pointing S. 40° W., belonging to the primary glaciation, the other S. 30° E., produced by later glaciers moving down the Bay." But for this supposed primary glaciation—*i.e.* by Dr. Croll's Ice-sheet—the striæ should be W.N.W.; and if a local glacier is required for the other set of striæ, there is no hill or valley pointed out, where one could have been formed.

On another part of the same island, striæ still more discordant occur, and of which the following curious explanation is offered (p. 792):—"Near Fethaland Point two sets of striæ were observed, which clearly prove the general movement of the ice during the primary glaciation, and at the same time a separate movement of the *lower* portions of the mass, caused by an *undertow*. On the headland north of the fishing village, the striæ run N.W. and N. 20° W.; while on the south of the bay, about a mile from the fishing station, the markings on the cliff-heads point N. 6° W.—N. 10° E., N. 20° W.;—indicating a varying movement in a northerly direction. On ascending the polished slope which overlooks the foregoing examples, the direction is S. 10°—35° W. This divergence is readily (*sic*) accounted for, by supposing that the *lower* current moved in a north and N.W. direction; while on the slopes of the ridge, the *upper* current moved towards the S.W., in harmony with the general movement along the Eastern Seaboard of the Mainland."

A more extraordinary physical phenomenon it is hardly possible to conceive than what is here described, viz. that at the place mentioned, this great *mer de glace* split and separated into two currents—one on the top of the other, and then flowed at right angles to one another. No suggestion is made as to the cause which could lead to such a phenomenon.

(2). Having thus shown that the direction of the *striæ* does not favour the advent of this great *mer de glace* from the N.E., nor its course across the islands to the N.W., let me notice shortly the statements in the paper, that the *Erratics and Drift* in the Islands confirm that theory.

As regards *Unst*,—where Messrs. Peach and Horne say the carry of the Boulders was *across* the island from the East to the West Coast,—the facts stated by Mr. Peach, *senior*, and not affirmed to be incorrect, are distinctly against that view.

A similar discordance exists in the Island of *Bressay*, which is also on the *Eastern* Seaboard. On it Messrs. Peach and Horne allow they found erratics which had come from the N.W.—brought, as they suggest, by the local glaciers of the Mainland;—of which glaciers, however, I respectfully repeat that I see no evidence given in the paper.

Therefore, neither at Unst nor at Bressay is the direction of the drift in accordance with Messrs. Peach and Horne's theory, which requires a movement from the *eastwards*.

Then, when the position of the Boulders found on the *Western* Seaboards is examined, they certainly do not show transport from the S.E.—which is stated to have been there the movement of the *mer de glace* across the islands. Messrs. Peach and Horne say that the "occurrence of these Boulders in the drifts on the West Coast, and as erratics on the hill tops, is due to the same cause, viz. to the westerly movement of the great *mer de glace*, which was powerful enough to over-ride the watershed" (p. 804).

The authors of the paper, though they refer in a footnote to "Hibbert's admirable volume on the Shetland Islands," curiously enough, omit notice of the Boulders which he observed on the Western Seaboards, and of the opinion he expressed as to the quarter from which they came. Thus, he says (Edin. Journ. of Science for 1831, vol. iv. p. 86), that in the "small Island of *Papa Stour*," composed of sandstone and secondary porphyry, "numerous fragments are found, even in the interior of the island, of a peculiar and very beautiful hornblende schist and actinolite schist, which is nowhere to be met with in this Archipelago, except at Hilswick Ness—a distance, when measured across the Bay of St. Magnus, of at least 12 miles. I also found that, besides these fragments, relics of other distant primary rocks were strewed about, less easily, however, to be identified than those which I have described." Dr. Hibbert adds, that if he is correct in believing that these schist blocks came across St. Magnus Bay from Hilswick, the agent which transported them moved from N. 47° E., a direction at right angles to the direction of the alleged Scandinavian Ice-sheet.

It appears that this same Island of *Papa Stour* was visited by Professor Geikie; and he too was struck with the number on it of "transported blocks of gneiss, schist, and other rocks foreign to the locality," thus confirming Dr. Hibbert's testimony as to the occurrence of Boulders there, transported from some distant point;—though he does not indicate the quarter from which they had probably come, beyond mentioning that the striæ on the rocks pointed N. 5° W.[1] (Nature, vol. xvi. p. 414).

Dr. Hibbert refers also to a transported Boulder on the summit of *Hilswick Ness;*—"a surprising block of granite removed from a rock, the nearest site of which is about 2 miles *north*" (Edin. Journ. of Science, vol. iv. p. 89).

"Again, in ascending *Roeness Hill*, composed of red granite, I was struck with the immense quantity of Boulders of a primary greenstone, which appear to have been removed from a site two or three miles off, and to have been rolled in a *southerly* or *south-westerly* direction up a gradual ascent of three or four miles" (Edin. Journ. of Science, vol. iv. p. 89).

If Messrs. Peach and Horne knew of these cases recorded by Hibbert, which are so discordant to their theory, why have they omitted to take special notice of them?

I may mention one other example, given in the Second Report of the Edinburgh Royal Society Boulder Committee. The Island of *Foula* is the most westerly of all the Shetlands, being about 20 miles from the nearest coast. It is said to be composed of Old Red Sandstone (Statistical Account of Scotland, vol. xv. p. 20). Mr. Russell, Schoolmaster, sent to the Committee a "Return" stating that there were on the island seven Boulders, some of granite, others of gneiss—two of 2 tons weight each—the others from 3 to 5 cwt. He suggested that the granite blocks came across the sea from Culswick, and the gneiss blocks from Delting, places bearing from Foula N.E. It is added that from the middle of the island, at a height of 700 feet, granite and gneiss drift occurs as far as the south end of the island.

These statements by Mr. Russell are quite at variance with the alleged movement of the Scandinavian Ice-sheet in the Western Seaboard; and, moreover, at variance with the striations given by the authors of the paper, which they represent as being "in *Foula* N.W. and W. 30° N." (p. 794).

Before leaving the subject of erratics, I must be excused for reminding Messrs. Peach and Horne that they have not answered or taken notice of the remark made in my Address, in reference to their repeated notices of Boulders, "*perched* on the *ridges* and even on the *tops* of the *highest hills*" (pp. 804–7). How is it possible to explain this fact on the supposition of a great *mer de glace,* which overrode the whole islands and "smothered them in ice"? Surely the effect of such an agency would be to sweep off from ridge and hill-top every particle of rubbish,—smooth the rocks, and leave no Boulders on them.

(3). The result of this examination of the striæ and transported Boulders in Shetland, seems to me to show, that the agency to which

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[1] This direction differs from that given by Messrs. Peach and Horne, who state that "in Papa Stour, the trend is N. or N. 28° W." Messrs. Peach and Horne could not have been aware of, or must have forgotten these remarks by Professor Geikie, when they state that "he carefully avoids expressing any opinion regarding the direction of the glaciation of these islands" (Geol. Mag. for Feb., p. 68).

they are to be attributed can be neither a great Scandinavian Ice-sheet, nor local glaciers. As Dr. Croll observes ("Climate and Time," p. 451), when referring to Shetland glaciation, the islands have no hills or valleys to form a gathering ground for glaciers; and even if in these islands glaciers could have been formed, they never could have crossed seas, with a depth of 50 or 60 fathoms, and for distances of from 12 to 20 miles, carrying Boulders and drift. The circumstances of the case seem rather to point to a time, when the islands were submerged in a sea with floating-ice, which, by the action of tides and currents, rafted fragments of rocks and rubbish from one island to another.

I very much regret if, in this my reply, I have said things which are disagreeable to the authors of this paper, especially considering the praiseworthy labour they bestowed, during four successive years, in examining the geology of these islands. Had the questions raised been merely as to the proper nomenclature of certain rocks, or of the fossils in them, there would not have been the same necessity for criticism. But the theory they have advocated regarding glaciation by this Scandinavian Ice-sheet, must, if true, entail important geological conclusions. The authors of the paper speak of the "*merit*" of Dr. Croll in having suggested this theory; and they probably went to the Shetlands so strongly prepossessed in favour of it, as to feel it to be alike a duty and a pleasure to gather facts tending to support the theory, and to supply arguments, and suggest ingenious hypotheses, with the view of obviating objections. They merely adopted Dr. Croll's theory, and he is more responsible for it than they are.

VI.—VOLCANIC HISTORY OF ICELAND.

By WM. GEORGE LOCK.

LOOKING carefully through Herra Thoroddsen's researchful and excellent paper, with the above heading, published in the October (1880) Number of the GEOLOGICAL MAGAZINE, I notice that two or three errors have crept in.

The most important oversight is Danish measure being given as English,thus the area of the large central lava-desert, the *Ódáðahraun*, is given at "sixty geographical square miles," whereas its real area is at least 1400 English square miles; while the area of *Askja*, the crater of a large volcano in the centre of the lava-desert, is given at "one square geographical mile," whereas it is at least twenty-three English square miles.

Having visited *Askja* twice, the first time in 1878, and again last summer, I should like to say a word or two about it, as nothing like an intelligible description of the volcano has, as yet, been published in English; and scientific men, therefore, have no idea of the magnitude and exact position of one which, as recently as 1875, erupted such a vast quantity of pumice and ash, that over 2000 square miles of country were covered to a depth varying from several feet to two inches; a lava-flood bursting forth, presumably from a rift in a subterranean channel connected with the volcano, at a spot distant therefrom twenty-five miles. I compute the bulk of the lava-flood that then issued at 36,000 of millions of cubic feet, the bed being between twelve and thirteen miles in length, from one to three in breadth, and varying in thickness from 300 to 37 feet.

It may be remembered that Mr. Wm. Lord Watts was the first Englishman, and indeed the first stranger, to visit *Askja*, and that he was so fortunate as to do so during the 1875 eruption. Upon his return he gave a short, but very imperfect, description of the volcano in a paper read before the Royal Geographical Society, likewise in a little work entitled "Across the Vatna Jökull." Mr. Watts's imperfect description is not to be wondered at, exploration being next to impossible at the time of his visit, immense masses of the mountain breaking away beneath his very feet. However, notwithstanding that five years have elapsed, it is the only account of the volcano that has been published in this country.

Mr. Watts speaks of *Askja* being inclosed with "sections of mountains," and Herra Thoroddsen writes that the *Dýngjufjöll* are "a complex of mountain-peaks rising up to 4500 feet high, inclosing the circularly formed valley called *Askja*."

This description does not convey a correct idea of these mountains, and *Askja*. The *Dýngjufjöll* (*fjöll* plural of *fjall* = to the Norsk *fjeld*) is the name given to a large mountain, whose *outer* circumference, at an altitude of 3500 feet (where it rises somewhat abruptly from a gentle slope formed of a succession of lava-flows which welled forth, in all probability, from *Askja* before the higher part of the mountain, which now incloses that crater, was built up by the upheaval of the masses of tuff and basaltic-lavas of which it is composed), exceeds twenty-four English miles, and a number of comparatively small semi-detached peaks stretching northward for several miles from the chief of the group. Within this large mountain lies *Askja*, which is unmistakably a crater; if being the outlet of a volcanic vent whence lava-flood after lava-flood has issued, both before and since the higher parts of the mountain were built up around the outlet, entitles such a place to that name.

The present floor of the crater consists of rugged beds of lava that have forced their way through earlier and more evenly deposited ones, and lies somewhat over 2200 feet above the level of the plain, 1500 feet, in which the mountain stands = 3700 feet above sea-level; and the crater's encircling mountain-wall is broken by gaps to the level of the surface lava in *Askja* in *two* places only; there is nowhere a gap or break in the mountain from the floor of *Askja* to the level of the plain of the *O'dáðahraun* to divide it into sections, therefore it is really a mountain, not a compound of mountains, and is indeed so shown upon the Danish map of Iceland published last year. The crater's encircling mountain-wall rises abruptly from the surface lava to heights varying from 800 to 1500 feet, = 4500 to 5200 feet above sea-level.

The "'dip' in the earth 750 feet 'down'" in the south-eastern part of *Askja* is an oval basin-like hollow formed by the subsidence of an immense mass of the lava deposits in the crater, five miles in circumference and of unknown thickness, which it is believed was torn from its bed by an explosion which took place—presumably in the volcanic vent beneath *Askja*—on the 4th January, 1875. This explosion caused an earthquake which opened rifts forty miles in length in the plains north of the *Dýngjufjöll*, and it was from fissures in a tract twenty miles in length and about three in breadth which sank to some depth between two of these rifts that the lava welled forth; pumice and ashes being alone ejected from *Askja*.

The site of the subsidence in *Askja* is now the bed of a tepid lake of considerable depth; the temperature of its water in 1878 was 97° Fahr.

The presence of this immense body of water within the crater of an active volcano is a most alarming feature; a comparatively slight eruption might be accompanied by an explosion that would further disturb the lava floor of *Askja*, which appears to be but a roof to an abyss in which molten matter, it is reasonable to believe, lies at no great depth, the contents of the lake would find its way below when a terribly violent eruption must inevitably ensue, one that will be likely to cause an earthquake to which that in 1875 will be comparatively insignificant, and likewise to affect the volcanic repose of Europe, by forcing back, by the violence of the concussion, the molten tide lying in the channel or channels, connected with the Earth's interior, underlying Europe; there being reason to believe that such do exist connected with the Icelandic volcanic vents, the great European earthquakes and volcanic disturbances having been either followed or preceded by terrific eruptions in Iceland, *e.g.* the earthquakes that destroyed Lisbon in 1755 were preceded by the commencement of a series of terrible eruptions from the *Kötlugjá*, which lasted a year; while thirty-two years later the Upper Calabrian earthquakes were followed by the outburst of prodigious lava-floods in the vicinity of the *Skaptárjökull.*

There are two strangely contradictory statements in Herra Thoroddsen's paper, with reference to the *Skaptárjökull*, "where," he says, page 465, "an eruption has never yet occurred," but on page 463 he credits the *jökull* under its other name of *Síðujökull* with an eruption in the year 1389–90, and also with an eruption in its vicinity in 1753. Upon all the maps of Iceland that I have seen the *jökull* is named "*Skaptár eða* (or) *Síðujökull.*"

VII.—SKETCH OF THE GEOLOGY OF BRITISH COLUMBIA.

By GEORGE M. DAWSON, D.S., A.R.S.M., F.G.S.

(Concluded from page 162.)

Cretaceous.—Lying everywhere quite unconformably below the Tertiary beds are the Cretaceous rocks, which constitute on the coast the true Coal-bearing horizon of British Columbia. These rocks probably at one time spread much more widely along the coast than they now do, but have since been folded and disturbed during the continuation of the process of mountain elevation, and have been much reduced by denudation. Their most important area, including the coal-mining regions of Nanaimo and Comox, may be described as forming a narrow trough along the north-east border of Vancouver Island, 130 miles in length. The rocks are sandstones, conglomerates, and shales. They hold abundance of fossil plants and marine shells in some places, and in appearance and degree of induration much resemble the true Carboniferous rocks of some parts of Eastern America. In the Nanaimo area the formation has been divided by Mr. J. Richardson as follows, in descending order:—

Sandstones, conglomerates, and shales	3290	feet.
Shales	660	,,
Productive Coal-measures	1316	,,
	5266	

The last named consists of sandstones and shales, and holds valuable coal-seams near its base. In the Comox area seven well-marked subdivisions occur, constituting a total thickness of 4911 feet.

Upper conglomerate	320	feet.
Upper shales	776	,,
Middle conglomerate	1100	,,
Middle shales	76	,,
Lower conglomerate	900	,,
Lower shales	1000	,,
Productive Coal-measures	739	,,
	4911	

The fuel obtained from these measures is a true bituminous coal, with—according to the analysis of Dr. Harrington—an average of 6·29 per cent. of ash, and 1·47 per cent. of water. It is admirably suited for most ordinary purposes, and is largely exported, chiefly to San Francisco, where, notwithstanding a heavy duty, it competes successfully with coals from the west coast of the United States, owing to its superior quality. The output of 1879 amounted to 241,000 tons, and is yearly increasing.

In addition to the main area of Cretaceous rocks above described, there are numerous smaller patches, holding more or less coal, in different parts of Vancouver Island, several of which may yet prove important.

In the Queen Charlotte Islands, Cretaceous rocks cover a considerable area on the east coast, near Cumshewa and Skidegate Inlets. At Skidegate they hold true anthracite coal, which, besides being a circumstance of considerable geological interest, would become, if a really workable bed could be proved, a matter of great economic importance to the Pacific coast.

At Skidegate, where these rocks are most typically developed, they admit of subdivision as follows, the order being, as before, descending:

A. Upper shales and sandstones	1500	feet.
B. Coarse conglomerates	2000	,,
C. Lower shales with coal and clay ironstone	5000	,,
D. Agglomerates	3500	,,
E. Lower sandstones	1000	,,
	13,000	

The total thickness is thus estimated at about 13,000 feet. With the exception of the agglomerates, the rocks in their general appearance and degree of induration compare closely with those of Vancouver Island. The agglomerates represent an important intercalation of volcanic material, which varies in texture, from beds holding angular masses a yard in diameter, to fine ash rocks, and appears at the junction to blend completely with the next overlying subdivision. These beds are generally felspathic, and often more or less distinctly porphyritic.

At the eastern margin of the formation the rocks lie at low angles, but become more disturbed as they approach the mountainous axis of the Islands, showing eventually in some cases overturned dips. It is in this disturbed region that the anthracite coal has been found, and from the condition of included woody fragments in the eastern portion of the area, it is probable that any coal seams discovered there would be bituminous, like those of Vancouver Island.

Though it was originally supposed that the anthracite occurred in several beds, it has, I believe, now been shown[1] that this appearance is due to the folding of a single seam which immediately overlies the agglomerate beds of subdivision D. The coal is associated with carbonaceous shales holding a species of *Unio*, but is succeeded, in ascending order, by beds charged with marine fossils, and fresh-water conditions are not known to have recurred at other horizons. It was where opened nearly vertical, and about six feet in thickness, but became thinner, and after about 800 tons of anthracite had been obtained, the mine was abandoned; the locality, however, still appears worthy of further and closer examination.[2]

In regard to the geological horizon of the different Cretaceous areas above described, the most complete information has been obtained for the Nanaimo and Comox basins. Large collections made by Mr. Richardson, in connexion with the work of the Geological Survey, have now been described by Mr. J. F. Whiteaves.[3]

These fossils are all from the lower portion of the formation, which is conclusively shown to represent the Chico group of the Californian geologists, which, with the locally developed Martinez group, is considered to be equivalent to the Lower and Upper Chalk of Europe. The highest subdivision of the Californian Cretaceous, the Tejon group, is supposed to represent the Maestricht, and in the absence of fossils from the upper portion of the Vancouver Island formation, it is possible that it may be equally young. The flora of the Vancouver Cretaceous consists largely of modern angiospermous and gymnospermous genera, such as *Quercus*, *Platanus*, *Populus*, and *Sequoia* ; several of the genera and a few of the species being com-

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[1] Report of Progress, Geol. Survey of Canada, 1878–79, p. 72 B.

[2] For further information on the Cretaceous rocks of the coast, see Dr. Hector's report in Palliser's Exploration in North America, and Quart. Journ. Geol. Soc. vol. xvii. p. 428. Reports of Progress, Geol. Survey of Canada, 1871-2, p. 75; 1872–3, p. 32 ; 1873-4, p. 94 ; 1874-5, p. 82 ; 1876-7, p. 160 ; the last reference being Mr. J. Richardson's complete report on the Nanaimo and Comox Basins, also pp. 119 and 144, 1878–9, p. 63B, a detailed report on Queen Charlotte Islands by the writer.

[3] Mesozoic Fossils, vol. i. part ii.

mon to it and to the Dakota group of the Middle Cretaceous of the interior region of the continent. The botanical evidence, while yet imperfect, is therefore by no means in contradiction to that afforded by the animals and the stratigraphy.

A number of fossils from the Queen Charlotte Islands have also been described and figured [1] from Mr. Richardson's collections made during a visit to the islands in 1872. Additional collections made by the writer in 1878, while considerably increasing the fauna, will enable more exact conclusions as to the horizon of the beds to be arrived at. There are few cases of specific identity between the forms in the Vancouver Cretaceous, previously described, and those of the Queen Charlotte Islands, the latter representing a lower stage in the Cretaceous formation. The plants found in these rocks, embracing numerous coniferous trees and a species of Cycad, also indicate a greater age than those of Vancouver.

The coal-bearing beds at Quatsino Sound on the west coast of Vancouver Island, have also yielded a few fossils. These consist chiefly of well-characterized specimens of *Aucella Piochii*, which occurs but sparingly in the Queen Charlotte Islands, and brings the rocks into close relations with the Aucella beds of the mainland of British Columbia, and in Mr. Whiteaves' opinion probably indicate an "Upper Neocomian" age. The rocks of the Queen Charlotte Islands and Quatsino may therefore be taken together as representing upper and lower portions of the so-called Shasta group of California, which in British Columbia can now be readily distinguished by their fossils.

On the mainland, developed most characteristically along the north-eastern border of the Coast Range, is a massive series of rocks first referred to by Mr. Selwyn, in the provisional classification adopted by him in 1871, as the Jackass Mountain group, from the name of the locality in which they are best displayed on the main waggon-road. The age of these rocks was not known at this time, but fossils have since been discovered in the locality above mentioned and in several others, the most characteristic forms being *Aucella Piochii* and *Belemnites impressus*. The rocks are generally hard sandstones or quartzites, with occasional argillites, and very thick beds of coarse conglomerate. A measured section on the Skagit includes over 4400 feet, without comprising the entire thickness of the formation. Behind Boston Bar, on the Fraser River, the formation is represented by nearly 5000 feet of rocks, while on Tatlayoco Lake it probably does not fall short of 7000 feet. At the last-named place these beds are found to rest on a series of felspathic rocks, evidently volcanic in origin, and often more or less distinctly porphyritic. On the Iltasyouco River, near the 51st parallel, and in similar relation to the Coast Range, an extensive formation characterized by rocks of volcanic origin, and often porphyritic, has also been found. Its thickness must be very great, and has been roughly estimated at one locality as 10,000 feet. It has been supposed, on lithological grounds, to represent the porphyritic

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[1] Mesozoic Fossils, vol. i. part i.

formation of the vicinity of Tatlayoco Lake, and fossils found in it have been described as Jurassic.[1] From analogy now developed with the Queen Charlotte Island fauna, however, Mr. Whiteaves believes that these beds are also Cretaceous.

Still further north the Cretaceous formation is not confined to the vicinity of the Coast Range, but spreads more widely eastward, being in all probability represented by the argillites and felspathic and calcareous sandstones of the Lower Nechacco; and, as the explorations of 1879 have shown, occupying a great extent of country on the 55th parallel about the upper part of the Skeena and Babine Lake. They here include felspathic rocks of volcanic origin similar to those of the Iltasyouco, which are most abundant on the eastern flanks of the Coast Range, and probably form the lower portion of the group. Besides these volcanic rocks, there is, however, a great thickness of comparatively soft sandstones and argillites, with beds of impure coal. The strata are arranged in a series of folds more or less abrupt, and have a general north-west and south-east strike. It is not impossible, from the general palæontological identity of the rocks of the interior with the older of those of the coast, that the Skeena region may eventually be found to contain valuable coal-seams, but this part of the country is at present very difficult of access, and there is no inducement to explore it.[2]

Rocks of the Vancouver and Coast Ranges.—Previous to the deposit of the Cretaceous, the older formations had been folded and disturbed, and were in degree of alteration much as at present. While there is therefore no difficulty in distinguishing the Cretaceous from the Pre-cretaceous rocks, the subdivision of the latter becomes in many instances a difficult matter, the generally wooded and inaccessible character of the country adding to the obscurity in many districts. Without therefore entering into detail in regard to the various groups, which it has been found necessary provisionally to constitute and name, I shall attempt to give a short connected sketch of these older rocks, beginning with those of the Coast. In 1872 Mr. Richardson described a section across the centre of Vancouver Island,[3] comprising a great thickness of beds which have been closely folded together and overturned. These consist of limestones, generally crystalline, but varying in texture and colour, interbedded with compact amygdaloidal and slaty volcanic rocks of contemporaneous origin. These are classed generally as "diorites" in the report cited, but admit of separation into several different species of igneous rocks, not here necessary to detail. Argillites also occur, but are apparently not prominent in the section. Fossils are found abundantly in some of the limestones, and though invariably in a poor state of preservation, the late Mr. Billings was able to distinguish, besides crinoidal remains,

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[1] Report of Progress, Geol. Survey of Canada, 1876-77, p. 150.

[2] I am indebted to Mr. J. F. Whiteaves for facts in regard to the palæontological evidence of the horizons of the subdivisions of the Cretaceous, communicated in advance of the publication of part iii. of the *Mesozoic Fossils*.

[3] Report of Progress, Geol. Survey of Canada, 1872-73, pp. 52-56.

a *Zaphrentis*, a *Diphiphyllum*, a *Productus*, and a *Spirifer*, and pronounced the beds to be probably Carboniferous in age.

Rocks belonging to the older series, unconformably underlying the Cretaceous, have now been examined in many additional localities on Vancouver Island, and, while no palæontological facts have been obtained to prove that they are older than those of the section above described, much circumstantial evidence has been collected to show that rocks even much more highly crystalline than those of the above section, and which, judged by standards locally adopted in Eastern America, would be supposed to be of great antiquity, represent approximately, at least, the same horizon.

At the south-eastern extremity of the island, in the vicinity of Victoria, a series of rocks occurs which was placed by Mr. Selwyn, in his provisional classification of the rocks of British Columbia, under the title of the *Vancouver Island* and *Cascade Crystalline Series.*[1] Mr. Selwyn, in speaking of these, remarks on their lithological similarity to the Huronian rocks, or those of the altered Quebec group of Eastern Canada. A somewhat detailed examination of this series has since been made, and shows it to be built up in great part of dioritic and felspathic materials, which in places become well characterized mica-schists, or even gneisses, while still elsewhere distinctly maintaining the character of volcanic ash-beds and agglomerates. With these are interbedded limestones, and occasionally ordinary blackish argillites. No more certain palæontological evidence of the age of these beds than that afforded by some large crinoidal columns which occur in the limestones, has yet been obtained. These, however, suffice to show that they cannot be referred to a pre-Silurian date, and it is highly probable that they are actually a more altered portion of the series represented in the first described section, from which their greatest point of difference is found in the smaller proportionate importance of limestones. They occur in the continuation of the same axis of elevation at no very great distance, and the greater disturbance which they have suffered would serve to account for the higher degree of alteration in materials so susceptible of crystallization as those of volcanic origin.

Elsewhere, in the vicinity of Vancouver Island, rocks holding fossils, which seem to be Carboniferous, and formed in part of volcanic materials, occur; and on Texada Island, beds probably of the same age are found, consisting of interstratified limestone or marble, magnetic iron ore, epidotic rock, diorite, and serpentine.

Passing north-westward, along the same mountainous axis, to the Queen Charlotte Islands, we find the rocks there underlying the Cretaceous Coal series to present, in the main, features not dissimilar to those of Vancouver Island. Massive limestones, generally fine-grained, grey, and often cherty, are folded together with felspathic and dioritic rocks, sometimes so much altered as to have lost the evidence as to whether they were originally fragmental or molten.

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[1] Report of Progress, Geol. Survey of Canada, 1871-2, p. 52.

In other places they are still well-marked rough agglomerates, or amygdaloids.

No characteristic fossils have been obtained from these rocks, but at the summit of this part of the series, and adhering closely to a limestone which apparently forms its upper member, occurs a great thickness of regularly-bedded blackish calcareous argillite, generally quite hard and much fractured, but holding numerous well-preserved fossils, including *Monotis subcircularis* and other characteristic forms of the so-called "Alpine Trias" of California and the 40th parallel region, which represents the Hollstadt and St. Cassian beds of Europe. The resemblance of the lower unfossiliferous rocks first described to the probably Carboniferous beds of Vancouver, leads to the belief that these may also be of the same age, while any slight unconformity between these and the Triassic may be masked by subsequent folding and disturbance.

In the extreme north-western part of Vancouver Island Triassic rocks like those of the Queen Charlotte Islands occupy extensive but yet undefined areas, while the slaty auriferous rocks of Leach River, near Victoria, may also represent the Triassic argillites in a more altered state.[1]

As already mentioned, Mr. Selwyn, in his provisional classification, unites under one title the older rocks of Vancouver Island, above described, and those which form the greater part of the Cascade or Coast Ranges. The progress in the investigation of the country seems to favour the correctness of this view, and to show a blending and interlocking of such characters of difference as the typical or originally examined localities of the two series present. Tracing the rocks eastward from the shores of Vancouver Island, we find them becoming more disturbed and altered, the limestones always in the condition of marbles, and seldom or never showing organic traces, the other rocks represented chiefly by grey or green diorites, gneisses—generally hornblendic—and various species of felspathic rocks, such as may well be supposed to have resulted from the more complete crystallization of the volcanic members of the series. Recurring in a number of places, and folded with these rocks, is a zone of micaceous schists or argillites.

The rocks classed as the Anderson River and Boston Bar series[2] in the provisional classification represent one fold of these schists, which may be supposed to be more or less exactly equivalent to the Triassic flaggy argillites of the first mountainous axis.

The Coast Range constitutes an uplift on a much greater scale than that of Vancouver and the Queen Charlotte Islands to the south-west of it, a circumstance which appears to have resulted in a more complete crystallization of its strata, and has also led to the introduction of great masses of hornblendic granite. These may in many places represent portions of the strata which have undergone incipient or complete fusion, in place. There is every evidence that in the Appalachian-like folding of this region the same rocks are

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[1] Reports of Progress, Geol. Survey of Canada, 1878-9, p. 46 B; 1876-7, p. 95.

[2] Report of Progress, Geol. Survey of Canada, 1871–2, p. 62.

many times repeated. East of the lower part of the Fraser River the folds have been completely overturned to the eastward.

These rocks of the Coast Range have with other features of the country a great extension in a north-east and south-east bearing, stretching, with an average width of 100 miles at least, from the 49th parallel to Alaska, a distance of 500 or 600 miles.

Pre-Cretaceous Rocks of the Interior.—North-east of the Coast Range the older rocks of the interior plateau are more varied, but have in their different developments characters in common with each other and with those of the Coast Range, which draw them closely together. These rocks, which were included under the Lower and Upper Cache Creek groups of the original classification, may be said as a whole, in their present state, to consist of massive limestones, diorites or allied materials, felspathic rocks, compact agglomeritic or slaty quartzites and serpentines. The last-named rock occurs in association with the contemporaneous volcanic materials, and doubtless represents the alteration product of olivine rocks. It is in beds of considerable thickness and wide-spread, and is of interest as being of a period so recent as the Carboniferous. The limestones are not unfrequently converted to coarse-grained marbles, and together with the quartzite appear in greatest force on the south-western side of the area they occupy. They have now been traced, maintaining their character pretty uniformly throughout, from the 49th to the 53rd parallel. Schistose, or slaty argillite rocks, which may represent those already described as folded with the Coast Range series, also occur, and a portion of these at least probably belongs to the overlying Triassic or Jurassic division.

In regard to the evidence of the age of the great mass of these rocks, forming the so-called Upper and Lower Cache Creek groups, the following points may be mentioned. A portion at least of the formation was in 1871 shown, by fossils collected by Mr. Selwyn, to belong to a horizon between the base of the Devonian and summit of the Permian. Additional fossils have since been procured, of which the most characteristic is the peculiarly Carboniferous foraminifer *Fusulina*. This has now been found in several localities, scattered over a wide area, and is associated at Marble Cañon with the remarkable *Loftusia Columbiana.*[1]

In the southern portion at least of the interior plateau region there exist, besides the Palæozoic rocks just described, and in addition to the probably in part Triassic argillites, extensive but as yet undefined areas of Triassic rocks of another character. These are in great part of volcanic origin, and have been designated the Nicola series. They have generally a characteristically green colour, but are occasionally purplish, and consist chiefly of felspathic rocks and diorites, the latter often more or less decomposed. The rocks are in some cases quite evidently amygdaloidal or fragmental, and hold toward the base beds of grey sub-crystalline limestone, intermingled in some places with volcanic material, and containing occasional layers of water-rounded detritus. The distinctly unconformable junction of this

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[1] Quart. Journ. Geol. Soc., 1879, p. 69.

series with the Cache Creek rocks is seen on the South Thompson, a few miles above Kamloops.

In the Gold Range which borders on the interior plateau to the north-east, the conditions found in the Coast Range appear in many respects to be repeated. The rocks just described, but with less quartzite and limestone, and probably an added proportion of volcanic material, are found in a more or less highly altered state as gneisses, dioritic, hornblendic, and micaceous schists, and coarsely crystalline marbles, while a belt of schistose and argillaceous beds, probably the same with that already several times referred to, and newer than the rocks just mentioned, is tightly folded with them, giving to this axis of elevation its famed auriferous character. No fossils have yet been found in the crystalline rocks of this range. Respecting the proved existence in it of a series of rocks older than elsewhere known in the province, the facts are given on a succeeding page.

For the region to the north-east of the Gold Range, including the eastern flanks of the range, and the country between it and the Rocky Mountains proper, little information has been obtained. It is one exceedingly difficult of access, owing to its mountainous and densely-wooded character; but the transition from the much-flexed rocks of the first-mentioned range to the comparatively little bent though much broken masses of the Rocky Mountains is probably pretty abrupt.

Structure of the Rocky Mountains.—In the Rocky Mountains we have the broken margin of the undisturbed sheets of strata which underlie the great plains, projecting in block-like masses. In British America our geological knowledge of the range is confined to the observations of its extreme northern part by Sir J. Richardson, of its southern portions by Dr. Hector, a traverse on the Peace River by Mr. Selwyn, and my own observations in the last-named locality and on the 49th parallel.

The most complete section is that in the vicinity of the 49th parallel,[1] to which I shall briefly refer, and then indicate points of difference between the rocks shown in it and those of the north-western continuation of the range. The total thickness of the beds here seen is about 4500 feet. The lowest are impure dolomites and fine dolomitic quartzites, dark purplish or grey, with a thickness of 700 feet or more. These may be of Cambrian age, and are supposed to represent the Pogonip formation of Clarence King's 40th parallel section.[2] Overlying this is a pale grey cherty magnesian limestone, with magnesian grits, estimated at 200 feet in thickness, which is supposed to represent the Ute-Pogonip limestone of Silurian age of the 40th parallel section. Next in order is 2000 feet or more of sandstones, quartzites, and slaty rocks of various tints, but chiefly

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[1] Though the investigation of the rocks of this part of the Rocky Mountains was carried on quite independently, and reported on in 1875, it has been thought desirable to refer the formations as far as possible to King's section, as being much the best hitherto published for the Rocky Mountain Region.

[2] Geol. and Resources of 49th Parallel, p. 56.

reddish or greenish grey, holding also magnesian grits, and a well-marked zone of bright red beds. These may be equivalent to the Nevada Devonian and Ogden quartzites of the same age, on the 40th parallel. The Carboniferous is next represented by a massive bluish limestone 1000 feet in thickness, above which lies an amygdaloidal trap 50 to 100 feet thick, which maintains its place for at least twenty-five miles along the mountains. Above this are flaggy beds of magnesian limestone and sandstone with red sandstone, which become especially abundant towards the top, the thickness of the series being about 200 feet. The position of the upper line of the portion of the formation which should be referred to the Carboniferous is uncertain, but it is probable that a part at least of the beds last described belong to it. Passing gradually upwards from this series is about 400 feet of beds, characterized by a predominant red colour, and chiefly thin-bedded red sandstones, often ripple-marked, and showing on some surfaces impressions of salt crystals. Fawn-coloured magnesian sandstones and limestones occur towards the top. These without doubt represent the Triassic or Jura-Triassic red beds extensively developed everywhere to the southward, in the eastern ranges of the Cordillera region.

North-westward, to the Athabasca River, Dr. Hector's numerous excursions in this mountain axis prove the great mass of the range to be composed of Carboniferous and Devonian beds, which are predominantly limestones, but it is also probable that some of the older rocks above described may occur.

In the Peace River region, on the 55th and 56th parallels, the conditions are somewhat changed. Massive limestones of Devonian and probably also of Carboniferous age, associated with saccharoidal quartzites, here form the axial mountains. On the west side these are overlain by an extensive schistose series, in which micaceous schists and argillites, more or less altered, predominate. These are known to occupy a long trough east of the Parsnip River, and cross the Misinchinka, with considerable width. They are doubtless of the same age as the gold-bearing schists of Cariboo, before referred to, and while no fossils have here been found in them, a series of dark argillites on the eastern slope of the mountain axis which contain several Triassic forms—more particularly the characteristic *Monotis*—may, it is supposed, represent the continuation of the same series in a less altered state. These marine *Monotis* shales, it will be observed, seem to represent in this section the red beds of the region further south. Volcanic material appears to be entirely absent from the limestone series.

While in the Rocky Mountains on the 49th parallel, formations extending downwards to the Cambrian have been identified with some degree to certainty, it will be observed that none older than Carboniferous or Devonian have so far been mentioned as occurring in other parts of the region. It is quite possible, however, that rocks of Silurian or even Cambrian age may exist, though the disturbed nature of the country has so far prevented their discovery. It has been attempted here merely to give a general sketch of the more important groups of rocks, which constitute the mass of the formations of the Province. Still older rocks, which may indeed represent part of the Archæan of the 40th parallel area, are known to occur, but about them little has yet been certainly determined. They appear at intervals in the Gold Range, and in the region between it and the Rocky Mountains. The rocks appear to be gneisses and granites, holding orthoclase felspar, and with abundant quartz and mica, very often garnetiferous and coarsely crystalline. They were originally classed with the schistose gold-bearing rocks of Cariboo and their representatives elsewhere, but we have already found reason to believe that these schists are much newer, and during the past summer those on the Misinchinka have been found to be charged with half-rounded quartz and felspar from the old rocks above mentioned, which must have been fully metamorphosed at the time of their deposition. A small area of these oldest and possibly Laurentian rocks occurs near Carp Lake in the northern part of the Province. They also exist in the Cariboo district, though they have not yet been defined there. They are described by Mr. Selwyn as occurring on the upper part of the North Thompson, and the gneissic rocks noted by Dr. Hector near the sources of the Athabasca, on the western side of the Rocky Mountain axis, probably belong to the same fundamental series.

Physical Conditions implied by the Deposits.—This review of the state of knowledge of the rock series of British Columbia may well be concluded by glancing rapidly at the physical conditions implied in the production of the different formations. The oldest land surface of which we have any knowledge is that of the probably Archæan rocks just described, and must have been in the region of the Gold Range of to-day. It may have extended farther westward in early Palæozoic time, forming a continental area like that supposed by King to have stretched west from the Wahsatch Mountains on the 40th parallel, but no trace of its existence to the eastward of the western margin of the Rocky Mountain Range has yet been found. In Devonian and Carboniferous times the geography of the region begins to outline itself more definitely. The probably Archæan rocks at this time formed a more or less continuous barrier of land along the line of the Gold Range, between the interior continental basin to the north-east and the Carboniferous Pacific to the south-west. In the eastern sea organic limestones with sandy and shaly beds were being deposited, and in the vicinity of the 49th parallel at least one well-marked flow of igneous material evidences the existence of volcanic phenomena. In the west and south-west of the land barrier the conditions were widely different. Here, too, limestones were in process of formation, but extensive siliceous deposits were also forming, while a great chain of volcanic vents—submarine or partly subaerial—nearly coincident with the present position of the Coast Range and those of Vancouver and the Queen Charlotte Islands. Trap and agglomerate rocks were thus added to the series. Similar centres of volcanic activity may have existed in the vicinity of the land barrier on the west, whilst the finer felspathic material affected the composition of the argillites and other rocks, in progress of deposition, even at a great distance from any of the vents, and the series acquired a great thickness.

Evidence of some disturbance at the close of the Carboniferous period is found in the unconformable superposition of the Nicola Triassic on these rocks, in the southern portion of the interior of the Province. This, however, appears to have affected the region to the west of the land barrier alone, and to have resulted in the more complete definition of this barrier, and probably to its increased elevation; for in Triassic and Jurassic times we find the deposition of the red beds and flaggy dolomitic limestones with salt, going on to the east near the 49th parallel, and further south the actual inclusion of salt and beds of gypsum, proving that this region was then a shallow inland sea cut off from communication with the ocean. To the west of the land barrier on the contrary, in the Triassic, and probably also in the Jurassic, a great thickness of volcanic rocks with limestones and argillites was being formed along the border of the Pacific. The argillites of this period probably afterwards became the chief gold-bearing formation of the country, as is proved to have been the case in California. These with the volcanic accumulations doubtless represent the Star Peak and Koipato groups of the Triassic as described by King on the 40th parallel between the Sierra Nevada and the Wahsatch Ranges; and though, as elsewhere stated,[1] I have not been able to find that the existence of Carboniferous volcanic rocks has been recognized in the Sierra Nevada of California, it seems probable, from the description and appearance of the rocks, that more or less altered volcanic materials, perhaps both of Mesozoic and Palæozoic age, enter into its composition. A further circumstance of interest in connexion with the Jura-Trias period is the evidence now obtained that the sea apparently spread uninterruptedly eastward across the Rocky Mountains and into the Peace River country, at least as far south as the 55th parallel. This is proved both by the lithological character of the rocks, and the fossils they contain,[2] and we thus arrive at an approximate definition, not only of the western but also of the northern limits of the great inland sea, which extended south-eastward to New Mexico, though we still remain ignorant of the precise character of the northern barrier. This period was closed by a great disturbance along the whole Cordillera region. In California the Sierra Nevada rose up as a mass of crumpled and compressed folds. In the southern part of British Columbia the disturbance affected the region from the Gold Range to the coast, extending the land area westward to the 121st meridian, and giving, so far as is known, the first upthrust to the mountains of Vancouver and Queen Charlotte Islands, but forming no continuous range where the great belt of coast mountains now is.

In the earliest beds of the Cretaceous there is evidence of a general slight subsidence in progress, with the formation of conglomerates, and we can trace the shore-line of the Cretaceous Pacific, which

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[1] Geol. Mag. 1877, p. 315.

[2] See, on the latter point, Report of Progress, Geol. Survey, 1876–7, p. 158.

crosses the 49th parallel near the 121st meridian, southward to the Blue Mountains of Oregon, south-westward to Mount Shasta, and from this, according to Whitney, still further southward along the western slope of the Sierra Nevada. To the north it appears nearly to follow the present north-eastern line of the Coast Range to the 52nd parallel, when it turns north-eastward, passing completely across the line of the Gold Range, and by straits and openings through the Rocky Mountains on the 55th parallel, connecting this with the great Cretaceous Mediterranean Sea of the interior of the continent. In the southern part of British Columbia it would appear that the Rocky Mountains proper were not at this time elevated, but that the Cretaceous Mediterranean washed the eastern shore of the Gold Range. In the Peace River region, however, just mentioned, there is ample proof that the Rocky Mountains formed even at this time a more or less continuous shore-line or series of islands, around which the Cretaceous beds were deposited.

The existence of a great thickness of rocks of volcanic origin in the Cretaceous of several parts of the Province has already been alluded to. Their resemblance to those described as occurring in the Cordillera region in Chile, by Darwin, has been pointed out by the writer in a former communication to the GEOLOGICAL MAGAZINE.[1]

The Cretaceous closed with another period of folding, in which additional height was given to the Vancouver and Queen Charlotte Island Ranges, the Coast Ranges were produced, as well as corrugations doubtless caused still further eastward which cannot now be separated from those of other periods. At this time, or shortly after, the Rocky Mountains attained their full height and development.

No trace of the earlier or Eocene Tertiary has been found in British Columbia, and it is probable that the Province was throughout at that time a land area. In the Miocene, the relative elevation of sea and land was much as at present, but the great inland lake formerly alluded to was in existence. This lake was doubtless the northern continuation or homologue of that which has been called the Pah-Ute Lake by Clarence King, and which lay east of the Sierra Nevada on the 40th parallel. The rocks formed in it thus represent the Truckee Miocene of King's section.

The Miocene closed with extensive volcanic disturbances throughout the country south-west of the Gold Range, and eventually by still another epoch of corrugation and crumpling probably synchronous with that which produced the Tertiary Coast Hills of California, and which may have given to the northern part of the coast the greater elevation, which it appears to have possessed during Pliocene times, when the wonderful system of fiords, by which it is now dissected, were cut out.

The most striking points brought out by the study of this region are probably the following. First, the repeated corrugation, parallel in the main to a single axis, which has occurred in the Cordillera region. Second, the occurrence of great and wide-spread masses of

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[1] GEOL. MAG. 1877, p. 314. The rocks elsewhere described were at the time the article in question was written supposed to be Jurassic.

volcanic material at at least four distinct horizons, proving the activity for an immense period of the volcanic forces along this portion of the Pacific margin. Lastly, the sometimes almost insuperable difficulty of distinguishing between volcanic rocks of different periods when they have suffered a like degree of metamorphism, and the inappropriateness of attempting to apply lithological standards, which have in eastern America or elsewhere been found locally useful in distinguishing between different series of crystalline rocks, in a region characterized by the abundance of easily crystallizable volcanic materials, and in which rocks of as late date as the Carboniferous have suffered a degree of metamorphism comparable to that of the Huronian or altered Quebec group of Eastern Canada.

REVIEWS.

I.—ON GOLD IN NATURE. [DELL' ORO IN NATURA, ETC.] By CHEV. WM. JERVIS, F.G.S., Conservator of the Royal Italian Industrial Museum in Turin, etc. Small 8vo. 204 pages, with Woodcuts and Tables. (Turin, Loescher; London, Trübner & Co.)

THIS history of Gold among ancient and modern nations, its geographical distribution, and its geological, mineralogical, and economical aspects, is an extension of a part of Prof. Jervis's public lectures at the Royal Museum in Turin, on the nature and geological bearings of mineral lodes and veins, and of detrital metalliferous formations, such as the alluviums and diluviums in which the precious metals and gems are so frequently met with. The lectures were new for Turin and attracted large audiences; but the subject of *Gold* alone is treated of in this published portion.

In writing his monograph on gold, the author has considered this metal historically, economically, and scientifically, but excluding its chemical relationship, as being so well known already. He has given a summary of the history of gold, both as extracted from its original beds, and as employed in society, from the earliest recognizable periods (as recorded in "Genesis"), through the several great nations of antiquity, down to the Fall of the Roman Empire. This summary is clear and useful, and not without some new historical considerations.

From the period last mentioned down to our own times the production of gold in different countries, and the modes of its occurrence, are treated of in successive chapters—under the following geographical headings—1. Japan, China, Siam, Eastern Archipelago, and Africa. 2. The lands discovered and opened up by Columbus, Cortez, and Pizarro in the 16th century. 3. Brazil, Uruguay, Guiana, Venezuela, Columbia, Ecuador, Chili, and Bolivia. 4. Europe and Asiatic Russia. 5. United States of North America, with California and conterminous territories. 6. Canada, British Columbia, and Nova Scotia. 7. Australia, Tasmania, and New Zealand. Necessarily the geological details and methods of digging, washing, and mining for gold are more fully given for Hungary, Russia and Siberia, California, and Victoria, than for other localities.

Statistics of gold-production in the second half of the 19th century in Hungary, in Russia, in California and elsewhere in the United States, in British Columbia, in Victoria, and in New South Wales, are shown in careful tables. The several kinds of gold, with specific gravity, per-centage of impurities, and other particulars and authorities, from forty world-wide localities, are given in another table. The numerous recorded nuggets of gold found in Russia, the United States, Victoria, and New South Wales, with their dates, localities, depth from the surface, weight, and carat-value, fill a large table of twelve pages. Another large table, with lithographed scales and graduated lines, exhibits the relative production of gold, from 1848 to 1880, both inclusive, in California, Australia, Russia, Siberia, British Columbia, and other countries.

From the Fall of the Roman Empire we find in history little about gold and gold-mining down to the time of Marco Polo's travels. Japan then comes into notice; and not long afterwards America and her gold-fields were visited by Europeans. In the preceding interval, gold was very scarce in Western Europe. The 17th century brought forward the Uralian and Siberian gold-deposits; and in the current half of the present century California and Australia displayed their vast gold-fields. Thus the order adopted by Chev. Jervis in the practical and economical history of gold is well considered and correct.

How far the possession of gold-mines may or may not benefit a state is briefly considered in a short chapter.

The author has added a polyglot vocabulary of the words used for gold by a hundred different tribes and nations. This has been enlarged from Christopher Keferstein's "Mineralogia Polygottica." A full index completes this small, but very useful and trustworthy Monograph on Gold. T. R. J.

II.—FOSSIL SPONGE SPICULES FROM THE UPPER CHALK. FOUND IN THE INTERIOR OF A SINGLE FLINT-STONE FROM HORSTEAD IN NORFOLK. By GEORGE JENNINGS HINDE, Ph.D., F.G.S. 8vo. pp. 83; Five Plates. (Munich, 1880.)

EVERY student of geology will be familiar with the sketch of the Chalk-pit at Horstead, drawn many years ago by the late Mrs. John Gunn, and of which a wood-engraving was published by Lyell, in his "Elements of Geology," and "Student's Elements." At that time the Chalk displayed a considerable number of the huge and remarkable flints called potstones or "Paramoudras," but during the progress of the working the number shown has decreased, and latterly but few have been obtained. Now the working of the Chalk at this old pit has been given up, but many "large variously shaped nodules of flint" remain, "strewn over the floor of the pit, after the removal of the soft chalk in which they had been imbedded." One of these, "about a foot in diameter, and more spheroidal than the generality of the potstones," attracted the attention of Dr. Hinde during a visit he paid to the pit a little time ago; it exhibited "a central cavity, which contained a quantity of material resembling fine flour in appearance and feel, and of a creamy-white tint." Carefully wrapping this material in a newspaper, he took away the prize, with the object of submitting it to minute investigation. The result is given in the work before us. The material when prepared for examination weighed about three or four ounces, and yielded a number of *Foraminifera*, and *Entomostraca*, fragments of *Echini*, *Annelida*, *Cirripedia*, *Polyzoa*, *Brachiopoda*, *Lamellibranchiata*, and Fishes; and in addition the beautifully varied Sponge-spicules, which Dr. Hinde has now figured and described. These spicules, which he studied at Munich with the hearty co-operation of Prof. Zittel, he has grouped under no less than twenty-one genera, including nine new species. In a postscript he refers to the recent work of Prof. Sollas (Ann. and Mag. Nat. Hist. ser. 5, vol. vi. pp. 384–395, 437–460), wherein that author describes a number of sponge-spicules from flint-nodules of the Chalk at Trimmingham in Norfolk. Prof. Sollas has placed them under seventeen genera, of which no fewer than thirteen are new, and Dr. Hinde admits that "nearly all the forms present at Trimmingham" are included among those he describes from Horstead. We must leave the students of sponges to settle these differences. Dr. Hinde discusses the difficulties that attend the exact identification of isolated spicules "from the fact that in the skeletons of both fossil and recent sponges, very many [foreign] spicules get intermingled with the sponge." "Another difficulty is owing to the fact of the same form of spicule being common to several different genera of sponges," while "in other sponges, there are six or seven different forms of spicule in the same species." But setting aside these perplexities, Dr. Hinde has done excellent service to science in developing and illustrating the treasures of this single flint-nodule from Horstead. Although he does not attempt to discuss in detail the question of the origin of the flints in the chalk, he makes some remark upon it, and observes "that the beautifully perfect state of preservation of the various delicate fossil organisms in the interior of this flint, when compared with the nearly complete obliteration of their structures in the enveloping chalk, points to the conclusion, that the period in which the flints were formed must have been previous to that consolidation of the mass of the chalk by which the smaller fossils were mostly destroyed." To the many interested in flint-formation, Dr. Hinde's work offers plenty of material for careful study, while at the same time it furnishes an excellent example of what may be done by patient investigation in a somewhat restricted field. H. B. W.

III.—JUNGLE LIFE IN INDIA; OR THE JOURNEYS AND JOURNALS OF AN INDIAN GEOLOGIST. By V. BALL, M.A., Geological Survey of India. 8vo. pp. 720. (London, De la Rue & Co., 1880.)

OUR Indian Geological Survey has now been in active progress for about a quarter of a century. As early as 1851, the late Dr. Oldham went to Calcutta for the purpose of making preliminary observations, but it was not until 1856 that he was enabled to establish a regular system of operations.[1] Since that period the important results of this Survey have been made known to us in the "Memoirs," "Records," and "Palæontologia Indica." The geologist in this country will perhaps have but a vague idea of the work that has to be carried on in order to interpret the structure of many parts of our Indian Empire. Here a sling-bag will contain all our needful apparatus, and we can pursue our observations over every acre of land. There one needs to be accompanied by a score or more of servants, including a native doctor, an elephant, bullocks, horses, dogs, and all the materials for camp-life; and there the chief geological sections are those exhibited in the river-channels. Here the structure, arrangement, and life-history of our great groups of rocks are well ascertained, and we are now entering into almost tedious detail and controversy in the naming and correlating of subdivisions, often but a few feet in thickness. There the majority of sections to be visited have been unseen by geological eyes, the rocks must be grouped in a large way, and the boundaries, that may often be accurately fixed in the rocky gorges cut out by the streams, must be marked across large tracts of country in accordance with the physical features, checked only by traverses here and there.

In the work before us Mr. Ball has given an account of his wanderings during a period of fourteen years, while engaged on the Indian Geological Survey. The account is made up of the notes extracted in chronological order from his Journals; and they relate chiefly to the Zoology, Botany, and Antiquities, besides which are not a few descriptive of the various tribes of men. Mr. Ball is an accomplished naturalist and evidently an ardent sportsman, though, whether he would or not, the encounters with many a tiger or bear, not to mention other unfriendly wanderers and visitants, were to be anticipated by one engaged in such districts as Mr. Ball had to examine. Snakes do not appear to have been so troublesome as most Europeans would expect.

The field-work of the Survey in Bengal usually commences about November and lasts until the end of April, by which time fever too frequently compels a speedy return to Calcutta. At all times, however, attacks of fever are sources of anxiety, and Mr. Ball mentions that during two months (November and December) in the Singhbhum district, out of twenty-seven men, only three escaped illness. A good deal of his attention was bestowed upon the Coal-districts; but as reports of all the explorations have been published, Mr. Ball here confines himself to brief and general notices of the geology. In the Bokaro Coal-field he mentions one seam 90 feet in thickness! The Raniguuj Coal-field, known as early as 1774, and worked a few years later, comprises an area of 500 square miles of coal-bearing rocks, and is known as the "black country" of India, being the largest and most important of the areas in which coal is worked.

Formerly a large proportion of the coal was obtained by quarries

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[1] See article on the Geological Survey of India, in the *Quart. Journ. Science*, Oct. 1870, p. 458.

and open workings, but most of the seams thus accessible have been exhausted, and regular mining is now carried on. None of the mines are of great depth, the "pillar and stall" system is generally adopted, and there is no danger from fire- or choke-damp. Upwards of 500,000 tons of coal have been obtained in one year, but the annual production appears to be decreasing. Some remarks on the Talchir Coal-field are also given.

Many notes on gold-mining, on workings for ores of iron, copper, lead, and manganese, and for diamonds, are included, as well as others upon the Metamorphic and Submetamorphic rocks, the Trap-dykes, and other geological features. Speaking of the Laterite rock seen at Midnapur, Mr. Ball notices the fact of its being unfossiliferous, and observes that its appearance seemed to favour the view of its having been formed by the deposition of volcanic ash in water.

The work itself will be read rather as a guide to the natural history of camp-life in India than as an exhaustive account of the district described (Western Bengal and the Central Provinces), for little or no attempt has been made to embody the records of others, the plan of the author being to confine himself to personal observations. Notes are also given of visits paid to the Andaman and Nicobar Islands. The work, which has assumed a formidable size, is one, however, that appeals to the naturalist rather than the general reader, who would doubtless find the scientific notes somewhat tedious. As a picture of the life of our geological brethren in India, it will interest many of our readers, some of whom, having spent many months in out-of-the-way parts of this country, will not be surprised to learn that camp-life in India is "at times a very dull, lonely, and monotonous one."

"But (as Mr. Ball observes) the life affords various compensations, without which it would be unbearable. To the lover of nature there are many attractions in it. There is a great, an indescribable pleasure in being the first to take up the geological exploration of a hitherto quite unknown tract—in being the first to interpret the past history of a portion of the earth's crust which no geologist has ever seen before." Nevertheless, one lacks the advantage, obtained in this country, of friendly recognition and criticism of his labours, and while enthusiasm in his work will carry a man through it, "Experience has shown how manifold are the risks to be encountered, while the term of service at present required, before a full pension can be earned, affords but a faintly-seen vision in the far-distant future of a home at home for one who has adopted the career of a geologist under the Government of India." Some attempts have been made to instruct natives in field-geology, but these do not at present appear to have been successful.

In conclusion we may mention that the book is handsomely "got up," and is accompanied by a map, eleven vignettes, and twelve plates, including two of chipped quartzite implements, polished celts, etc.

H. B. W.

IV.—AN ABSTRACT OF THE GEOLOGY OF INDIA. By P. M. DUNCAN, M.B. (Lond.), F.R.S., F.G.S. Third Edition. (London, 1881.)

THIS work is chiefly intended as a text-book for the students of the geological class at the Indian Engineering College, but the geologist and general reader will find it also a clear and concise abstract of the present established facts in Indian geology, and a useful summary of the larger and more detailed Manual by Messrs. Medlicott and Blanford, noticed in this MAGAZINE (February and March, 1880). The present edition has been carefully revised by Prof. Duncan, and contains much additional matter and some alterations, necessitated by the publication of the official Manual above referred to, and from which excellent book the author fairly acknowledges many pages of his abstract are derived. India may be naturally divided into three regions, the Peninsular, Extra-Peninsular, and Indo-Gangetic; the distinctness in the geological structure and physical features of the two former is very marked, the latter is a vast alluvial plain, due to a depression which has been more or less filled up with the alluvia of the rivers of the other regions flowing into it. The geology of these three regions is described in a series of chapters commencing with the recent deposits, and proceeding in descending order with the Tertiary, Cretaceous, Jurassic and underlying series, followed by descriptions of the Peninsular Coal-fields, their fauna and flora, and of the Azoic and Metamorphic rocks of the two regions. The work will be a useful guide to the general facts of Indian geology, as regards the nature, character, and arrangement of the crystalline, metamorphic, and sedimentary rocks of India. Besides classified lists of the formations of Peninsular and Extra-Peninsular India, a table is given showing the equivalents (homotaxially considered) of the formations compared with those of Europe. J. M.

REPORTS AND PROCEEDINGS.

INTERNATIONAL GEOLOGICAL CONGRESS.

IN the GEOL. MAG. for December, 1876 (Decade II. Vol. III. p. 573), attention was drawn to certain proposals made for the holding of an International Geological Congress at Paris in 1878, whose purpose should be to consider the many obscure points in geological classification and nomenclature. The Congress was duly arranged, opened, and carried on for six days, under the Presidency of Prof. Hébert. At the concluding sitting it was resolved that a Second Session should be opened at Bologna, September 29, 1881. His Majesty the King of Italy has consented to be Patron of the Congress, and Signor Q. Sella has been nominated President.

Two principal subjects were proposed by the Congress of Paris for discussion, and each was referred to an International Commission named by the Congress; they were as follows:—

1. *Geological Cartography:* to consider the possibility of the adoption of a common system of signs and colours.

2. *The Unification of Geological Nomenclature:* to consider all matters relating to stratigraphical classification and nomenclature, and so far involving an inquiry into the value and significance of petrological and palæontological characters. Prof. T. M'K. Hughes was appointed the Commissioner on the Unification of Geological Nomenclature for Great Britain, and he was requested to organize a Committee to report upon the different Geological subdivisions, and on the various details bearing upon the questions of classification and nomenclature. Acting in conjunction with Prof. Prestwich, he has accordingly formed a Committee which has met on several occasions in London.

The matters at present discussed have been the definition of the terms:—System, Formation, Terrane, Deposit, Bed, Layer, Rock, Group, Series, Zone, Horizon, Period, Age, Epoch, Era, Time, Cycle, Date, etc. The organization of Sub-committees has also been carried on, and one or more Reporters have been attached to each (after the plan adopted by Committees of the British Association), to collect the information from the several members composing it, and to draw up the Reports. The following Reporters were appointed:—Committee to consider *Recent and Tertiary*, J. Starkie Gardner and H. B. Woodward; *Cretaceous*, W. Topley and A. J. Jukes-Browne; *Jurassic*, W. H. Hudleston and the Rev. J. F. Blake; *Trias and Permian*, C. E. De Rance and the Rev. A. Irving; *Carboniferous, Devonian, and Old Red Sandstone*, G. H. Morton and A. Strahan; *Silurian, Cambrian and Pre-Cambrian*, C. Lapworth and J. E. Marr; *Petrology and Mineral Veins*, H. Bauerman and T. Davies.

The duty of the Sub-committees will be (1) To draw up a list of the names now in use for each formation, and for its subdivisions; (2) To ascertain the true significance of such names or terms, giving reference to the authors by whom they were used in the first instance, or subsequently with a modified meaning; (3) To investigate the synonymy of the names, firstly in regard to the British rocks, and afterwards in regard to equivalent beds in foreign countries; (4) To offer suggestions for the unification of the Nomenclature.

Through the liberality of His Majesty the King of Italy, the Italian committee of organization are able to offer a prize of 5000 francs for the best suggestion for an international scale of colours and conventional signs practically applicable to geological maps and sections, including those of small scale. The index of colours and signs should be accompanied by maps representing regions of varied geological structure, and by an explanatory memoir in the French language. The documents should be marked with a motto, which should be placed on the outside of an envelope containing the name of the author, which will not be opened until the Congress, when the name of the successful competitor will be made known. The index and accompanying papers should be sent in to Prof. J. Capellini, Director of the Museum at Bologna, by the end of May. The award will be made by a jury of five chosen from the presidents of sub-commissions. Should no index be thought worthy of the grand prize, the best will receive a gold medal of the value of 1000 francs, while the two next will be given medals of silver and bronze of similar shape.[1]

GEOLOGICAL SOCIETY OF LONDON.

I.—March 23, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read :—

1. "The Upper Greensands and Chloritic Marl of the Isle of Wight." By C. Parkinson, Esq., F.G.S.

In this paper the author described the Upper Greensand as exposed at St. Lawrence and along the Undercliff. At the base of the St. Lawrence cliff there are hard bands of blue chert, from which astaciform Crustacea have been obtained ; and quite recently, in a large boulder of the same material lying on the beach, there were found the remains of a Chelonian, referred by Prof. Owen to the family Paludinosa, and named by him *Plastremys lata.* The presence of these freshwater organisms was thought to imply a connexion with the Wealden continent. The chert-bed, 2 feet thick, was regarded by the author as marking the boundary between the Gault and the Greensand. Above it the author described 56 feet of compact red and yellow sands, of which the first 20 feet are un-fossiliferous, the upper 32 feet show traces of organic remains; between them there is a fossiliferous zone 4 feet in thickness, containing *Ammonites inflatus*, *A. auritus*, and species of *Panopœa*, *Cucullœa*, *Arca*, and *Trigonia*, and immediately below this a separate band containing an undetermined species of Ammonite. These sands are followed by 38 feet of alternate beds of hard chert and coarse greensands, having at the bottom 6 feet of inferior building-stone, surmounted by 5 feet of freestone. The latter contains *Ammonites rostratus*, and the cherts various fossils, chiefly bivalves. *Clathraria Lyelli* also occurs at this level. Above the greensands come 6 feet of chloritic marl :—the upper 3½ feet fossiliferous, with a base of hard phosphatic nodules containing crushed specimens of *Pecten asper* ; the lower 2½ feet compact, with darker grains and few fossils. The author compared the sections of this series given by Capt. Ibbetson and Dr. Barrois ; his own views closely correspond with those of the latter writer.

2. "On the Flow of an Ice-sheet, and its Connexion with Glacial Phenomena." By Clement Reid, Esq., F.G.S.

The author considers that the Boulder-clays have been formed beneath an ice-sheet, and consequently there must have been formerly a huge mass of ice, which would have to flow 500 miles on a nearly level surface, and then to ascend a gentle slope for nearly another 100 miles. He does not think a great piling up of the ice at the north pole can be assumed to account for this motion. This he explains by the gradual passage of the earth's heat through the mass of ice, raising the temperature of the whole instead of liquefying the surface-layer. As the heat passes upwards, it raises the

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[1] This last paragraph we extract from an article in "Nature," March 31st, 1881, by Mr. De Rance.

temperature of a particular layer, causes it to expand, and so to put a strain upon the layer above, and then to rupture it. The broken part spreads out, reunites by regelation, and then receiving the heat from the layer below again expands and ruptures the layer next above. Thus the movement is from the base upwards, rather than from the surface downwards.

The author estimates that the ice-sheet in Norfolk was only about 400 feet thick, because Boulder-clay does not appear above that level, but only coarse Boulder-clay; in North Yorkshire it extends up to about 900 feet. The author considers that the shell-beds of Moel Tryfaen were not deposited under water, but thrust up-hill by this advancing ice-sheet.

3. "Soil-cap Motion." By R. W. Coppinger, Esq. Communicated by the President.

The author described numerous cases in Patagonia where the stumps, etc., of trees are to be seen in the marginal waters of the sea and of lakes. These, together with stones and rocks, sometimes simulating perched blocks, he considers to have been brought down by the motion of the soil-cap—a thick spongy mass resting upon rock often worn smooth by the action of ice, and so sliding down the more easily under the influence of vegetation. The appearances are not unlike those due to subsidence; but he points out that all the evidence is in favour of recent upheaval, instead of subsidence.

II.—April 6, 1881.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "The Microscopic Characters of the Vitreous Rocks of Montana, U.S." By F. Rutley, Esq., F.G.S. With an Appendix by James Eccles, Esq., F.G.S.

The specimens described were collected by Mr. J. Eccles, F.G.S. They consist of various obsidians and rhyolites, some of them porphyritic or spherulitic, which appear to throw some light on the epoch at which these structures have been set up. In a black porphyritic obsidian is a crystal which the author believed to be olivine. Zirkel has already noticed the occurrence of this mineral in a trachyte. The structure of some of the above indicates that it is extremely difficult to draw hard and fast lines between trachytic rhyolites and felstones. A tuff containing fragments of a rhyolite, some perlitic, was also described. The spaces included within the boundary of some of these perlitic cracks exhibit depolarization and sometimes interference-crosses. The author considered these to be the result of strain in contraction, and connected with incipient crystallization.

Andesites, from two localities in the northern part of the Yellowstone district, were also described.

In an appendix Mr. Eccles briefly described the geology of the region from which the above specimens were collected, referring for greater detail to the memoirs of Dr. Hayden and his fellow-workers. In the Yellowstone-Park region trachyte and obsidian (the latter being the upper) form an irregular plateau, resting on rocks of Carboniferous age; no vents were observed; but Mount Washburne, a few miles distant, is a broken-down volcanic cone, from which both trachyte- and basalt-flows (the latter the newer) have proceeded.

2. "On the Microscopic Structure of Devitrified Rocks from Beddgelert, Snowdon, and Skomer Island." By F. Rutley, Esq., F.G.S.

The first specimen described was found about a quarter of a mile from Beddgelert, on the Capel Curig road. Examined microscopically, it showed traces of perlitic structure, with small spherulites, both isolated and in bands, not exhibiting radial structure, but apparently composed of very minute chlorite and a garnet, probably spessartine. Hence the rock must be a devitrified obsidian or pitchstone. The second specimen is a banded greenish-grey "felstone," at Clogwyn du'r Arddu, of Bala age, which also has probably been vitreous. The third specimen, from near Pont y Gromlech, is a schistose felsitic rock. This was compared microscopically with an obsidian from Hungary and a rhyolite from Gardiner's River (N. America), and was shown to have been probably once a glassy rock. In conclusion the author discussed the limits of the terms felstone, rhyolite, trachyte, and obsidian.

An appendix was added upon the microscopic characters of some rocks from Skomer Island, off the coast of Pembrokeshire. These were shown to be devitrified obsidians, some of them exhibiting spherulitic and perlitic structures. A trachytic rock and a basalt from the same locality were also described.

3. "The Date of the last Change of Level in Lancashire." By T. Mellard Reade, Esq., C.E., F.G.S.

The author described some observations made by him at Blundellsands, on the coast of Lancashire, near Liverpool, according to which, judging from the position of high-water mark, the land had gained considerably upon the sea between 1866 and 1874. At one end of a length of 350 yards, spring-tide high-water mark had receded 15 yards, and at the other end 5 yards. The author estimated that the deposit of sand that had accumulated in 8 years amounted to an average of 10 yards wide and 2 yards deep. Allowing a further depth of 1 yard for sand that may have been blown over the top, he finds 10,500 cubic yards as the quantity of sand deposited in 8 years on a shore-frontage of 350 yards, or 3·75 cubic yards per yard of frontage per annum. Applying this unit of measurement to the 16 miles of coast forming the western boundary of the deposit, he gets 105,600 cubic yards as the quantity of sand annually moved; 22 square miles of sand, 12 feet thick, give 272,588,800 cubic yards of sand accumulated, which, divided by the annual quantity, will give 2580 years as the age of the whole deposit of blown sand. The author adduced other evidence in support of his view, and concluded that if the last change of level in South-west Lancashire was a downward one, it could not have taken place within 2500 years.

CORRESPONDENCE.

THE PRE-CAMBRIAN ROCKS OF ST. DAVIDS AND OF BOHEMIA.

Sir,—I cannot find that the letter of Dr. Hicks in your last issue materially strengthens the proof for the Dimetian age of the gneissic series which underlies the Bohemian Pebidian. Dr. Hicks maintains that the St. Davids Dimetian is a true gneiss. I cannot of course say that the rock in the few sections which I did not see is not foliated; but I saw no true foliation in the principal localities named in his papers, and I cannot discover anything about foliation in the microscopic descriptions of Mr. T. Davies, Prof. Bonney, and Mr. Tawney. It is at any rate certain that if these rocks are schists, their foliated structure is of the obscurest possible character, and quite unlike that of the true gneisses.

I quite agree with Dr. Hicks that we are not to expect "absolute identity," but I deny that there is even a "general resemblance" between the Dimetian of St. Davids and the gneissic rocks of Bohemia, so far as we can judge from Mr. Marr's descriptions. Nor do I think that a similarity of the conditions of deposit, even if proved, goes for much. I presume that most arenaceous rocks, from the Tertiary downwards, were laid down in comparatively shallow water.

That the Bohemian gneiss unconformably underlies the Pebidian, simply proves that it is pre-Pebidian. I do not deny its Dimetian age; indeed, I think it highly probably that Mr. Marr is right; but, as we do not yet know how many gneissic series lie below the Cambrian, I demur to the assumption that any Archæan gneiss group which is not Lewisian must be Dimetian. Any resemblance to the newer gneiss of the Highlands can have no decisive value in our present uncertainty of the age of that formation. These Archæan groups are a very complicated study, and more haste may sometimes prove to be the worse speed. The researches of Dr. Hicks have done much towards unravelling the Archæan mystery, but we must work along our clues with great caution, else we shall become the sport of the Philistines who would condemn us to grind in the prison-house of an eternal Siluria. C. Callaway.

Wellington, Salop, *March 5th*, 1881.

OBLIQUE AND ORTHOGONAL SECTIONS.

Sir,—In my short notice about the section of a folded plane there is an error which Mr. Day has not pointed out. I did not expect that what I had written would have attracted attention; but since it has done so, I may ask to be allowed to say, in the sixth line from the bottom of p. 21, *dele* "$=\theta$," and in the fifth, for "θ" read "$EAB=\theta$ suppose."

I cannot exactly see that Mr. Day's proof gives my second equation, because his α, β, and ϕ do not appear to be the same angles as in my demonstration.

The method of the shadow is ingenious and of course correct.

Harlton, *4th March*, 1881. O. Fisher.

JOHN J. BIGSBY, M.D., F.R.S., F.G.S., F.R.G.S.

Born Aug. 14th, 1792; Died Feb. 10th, 1881.

Dr. J. J. Bigsby was the son of J. Bigsby, Esq., M.D., Edinburgh. He was born at Nottingham, on the 14th August, 1792, and early followed the career of his father by entering the Medical Profession, and shortly after taking his degree, he was appointed about 1818 as Medical Officer to a German Rifle Regiment in the English Service and ordered to Canada. Soon after his arrival he was sent by the Governor to Hawkesbury Settlement, where there had been an outbreak of typhus fever. In the following year the more agreeable task was assigned to him of travelling through Upper Canada to report upon its Geology. A part of the collections he then made are still preserved in the British Museum, not the least interesting of which are the curious siphuncles of *Huronia Bigsbyi*, from Drummond's Island, Lake Huron. About the year 1822 he was appointed British Secretary and Medical Officer to the Canadian Boundary Commission. In 1823 he was elected a Fellow of the Geological Society of London, to whose Transactions he had already been a contributor.

Dr. Bigsby returned to England about 1827, and commenced to practise as a medical man at Newark. In 1846 he came to reside in the metropolis, and from that date identified himself with most of the scientific societies in London. In 1850 he published the account of his experience of life and travel in North America, under the title of "Shoe and Canoe."

His first scientific paper appeared in Silliman's American Journal in 1820, and he contributed altogether about twenty-seven papers to learned societies in London and elsewhere. His most important scientific work appeared in 1868, entitled "Thesaurus Siluricus," being a list of all the fossils which occur in the Silurian formation throughout the world. He was elected a Fellow of the Royal Society in the following year, and was awarded the Murchison Medal in 1874 by the Council of the Geological Society.

In 1878 he published his second catalogue, entitled "Thesaurus Devonico-Carboniferus," and at the time of his death had far advanced towards the completion of his third volume, the "Thesaurus Permianus."

In 1876 he requested the Geological Society to accept, in trust, a sum of money to provide a medal to be called the "Bigsby Medal," and to be awarded biennially to some geologist not more than forty-five years of age of any nationality; Prof. Marsh, Prof. Cope, and Dr. Barrois having been up to this time the three recipients. Dr. Bigsby died at his residence, 89, Gloucester Place, Portman Square, at the good old age of 89 years.

PROFESSOR JAMES TENNANT, F.G.S., F.C.S.,

Born 1808; Died February 23rd, 1881.

During the earlier part of the present century the science of Mineralogy had no more claim to be considered one of the exact sciences than has Geology at the present day. To be able to identify minerals "at sight," and to test them by their hardness, lustre, form, and weight, represented the common extent of a collector's acquirements. But few understood the use of a goniometer, and not many could use the blowpipe, or correctly make an analysis of a mineral in this country. It was young James Tennant's lot to come to London at an early age, and enter the service of Mr. Mawe, the well-known Mineralogist, whose shop was a centre of resort for men of science. The stock-in-trade consisted of shells, minerals, marbles, etc., most of which Mr. Mawe obtained during his frequent travels. Here Tennant gained his first acquaintance with minerals. The classes of the Mechanics' Institution which he joined, and attendance on Faraday's lectures at the Royal Institution, improved his education, and enlarged his scientific knowledge of the specimens in which his master dealt. At Mr. Mawe's death, the management of the business devolved upon Tennant, who shortly after succeeded to it as proprietor.

He derived much advantage from the friendship of Sir Everard Home, whose knowledge of crystals enabled him to impart much valuable information to Tennant.

When King's College opened in the Strand, the Council desired a teacher in Mineralogy, and applied to Faraday for his nomination of a fit person; his recommendation was in favour of Mr. Tennant, who shortly after his appointment received the title of "Professor of Mineralogy." The new position opened a wider field of usefulness and of interesting study. His after-life was devoted to the diffusion of knowledge relating to mineralogy and geology, and many of the students who attended his lectures proved that he had not taught in vain by turning out to be useful collectors and observers of minerals abroad. He was one of the strong promoters and believers in the discoveries of Diamonds in South Africa, at a time when others denied their genuineness.

Professor Tennant was a very ardent advocate of technical education, and having seen the valuable application of the lathe in cutting both diamonds and other valuable stones and marbles, he induced the Turners' Company to promote the advancement of turning, by offering prizes annually for specimens in all branches of the turner's art. Great credit is due to Prof. Tennant for the revival of this branch of technical education as applied to ornamental work of all kinds and materials.

He was one of the founders of the Geologists' Association, of which body he was formerly President. He was also for several years a member of the Council of the Geological Society of London.

SIR PHILIP DE MALPAS GREY-EGERTON, BART., M.P., F.R.S., F.G.S.,

OF OULTON PARK, TARPORLEY, CHESHIRE.

BORN NOV. 13TH, 1806; DIED APRIL 5TH, 1881.

ANOTHER distinguished name has been erased by death from the list of Fellows of the Geological Society. Sir Philip Egerton was the eldest son of the Rev. Sir Philip Grey-Egerton, by his wife Rebecca, youngest daughter of the late Josias Dupré, Esq., of Wilton

Park, Bucks; he was educated at Eton and Christ Church, Oxford, graduating B.A. in 1828. Having studied geology under Conybeare and Buckland, together with the Earl of Enniskillen, he made a lengthened geological tour with that nobleman through Germany, Switzerland, and Italy. About this time he became acquainted with Professor L. Agassiz, at Neufchatel, and commenced the formation of a grand collection of Fossil Fishes, both from British and Foreign localities. A large number of the types of Agassiz's Monograph on the "Fossil Fishes of the Old Red Sandstone" (published in 1844) are to be found in the Enniskillen and Egerton Collections, as also of specimens described and figured in the Decades and Memoirs of the Geological Survey, the Quart. Journ. Geol. Soc., the GEOLOGICAL MAGAZINE, etc. He entered Parliament in 1830 as Member for Chester, and he afterwards represented the Southern and Western Divisions of Cheshire since 1835.

He was senior elected Trustee of the British Museum, and one of the Original Trustees of the British Association, and of the Royal College of Surgeons of London, and a Member of the Senate of the University of London.

He was elected a Fellow of the Geological Society in 1829, and of the Royal Society in 1831, to the Proceedings of both which he has been a frequent contributor.

Having been almost always a Member of the Council of the former Society, an opportunity only occurred to award him the Wollaston Medal in 1873. The first Kingsley Medal was also presented to him in 1878, by the Chester Natural History Society, in recognition of his valuable services in promoting the objects of that Society.

During the long period which he served as a Member of Parliament, although not distinguished in debate, he was nevertheless one of the hardest workers in Committees of the House, and whether as a naturalist, or antiquary, a field-sportsman, or country gentleman, he was always thoroughly in earnest in all he undertook.

His career was an eminently useful and practical one, and his loss in the world of science, as well as of politics, will be keenly felt; but most severely by the circle of his most intimate friends who had grown to know and value him for his private character, and the noble example he set as a thorough and upright English gentleman.

He worthily did honour to the motto of his ancient house:—

"I trust not in arms but in virtue."

MISCELLANEOUS.

A DEEP COAL-MINE.—It is interesting to record a triumph of engineering skill and perseverance. On Saturday, March 5th, at the Ashton Moss Colliery, in Lancashire, the main seam of coal was cut at the depth of 2691 feet. This is the deepest pit in the United Kingdom, Rose Bridge Colliery, which was the deepest previous to this sinking, being only 2460 feet. The temperature in the Ashton Moss Colliery at 860 yards was 78° Fahr.—*Athenæum*, March 19.

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. VIII.

No. VI.—JUNE, 1881.

ORIGINAL ARTICLES.

I.—Subsidence and Elevation, and on the Permanence of Oceans.

By J. Starkie Gardner, F.G.S.

THE theory of permanent Continents and Oceanic basins, opposed as it is to the general teaching of text-books, seems to have given rise to comparatively little discussion. In the latest edition, for instance, of Lyell's Principles, we read: "It is not too much gratuitous, and entirely opposed to all the evidences at our command," the supposition that temperate Europe and temperate America, Australia and South America, have ever been connected, except by way of the Arctic or Antarctic Circles, and that—lands now separated by seas of more than 1000 fathoms depth have ever been united.

Notice.—The Chromo-Lithographic Plate intended to accompany Mr. J. S. Gardner's paper, not being ready in time to appear in this month's Magazine, will be issued in our next number, for July.—Edit. Geol. Mag.

Mr. Wallace, it must be admitted, has succeeded in explaining the chief features of existing life distribution, without bridging the Atlantic or the Pacific, except towards the Poles, yet I cannot help thinking that some of the facts might perhaps be more easily explained by admitting the former existence of the connexion between the coast of Chili and Polynesia and Great Britain and Florida, shadowed by the sub-marine banks which stretch between them. Nothing is urged that renders these more direct connexions impossible, and no physical reason is advanced why the floor of the Ocean should not be upheaved from any depth. The route by which the floras of South America and Australia are supposed to have mingled is beset by almost insurmountable obstacles, and the apparently sudden arrival of a number of sub-tropical American plants in our Eocenes, necessitates a connexion more to the south

Park, Bucks; he was educated at Eton and Christ Church, Oxford, graduating B.A. in 1828. Having studied geology under Conybeare and Buckland, together with the Earl of Enniskillen, he made a lengthened geological tour with that nobleman through Germany, Switzerland, and Italy. About this time he became acquainted with Professor L. Agassiz, at Neufchatel, and commenced the formation of a grand collection of Fossil Fishes, both from British and Foreign localities. A large number of the types of Agassiz's Monograph on the "Fossil Fishes of the Old Red Sandstone" (published in 1844) are to be found in the Enniskillen and Egerton Collections, as also of specimens described and figured in the Decades and Memoirs of the Geological Survey, the Quart. Journ. Geol. Soc., the GEOLOGICAL MAGAZINE, etc. He entered Parliament in 1830 as Member for Chester, and he afterwards represented the Southern and Western Divisions of Cheshire since 1835.

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I.—Subsidence and Elevation, and on the Permanence of Oceans.

By J. Starkie Gardner, F.G.S.

THE theory of permanent Continents and Oceanic basins, opposed as it is to the general teaching of text-books, seems to have given rise to comparatively little discussion. In the latest edition, for instance, of Lyell's Principles, we read: "It is not too much to say that every spot which is now dry land has been sea at some former period, and every part of the space now covered by the deepest ocean has been land." The new theory has been upheld chiefly by Sir Wyville Thomson, Prof. Geikie and Mr. Wallace. The latter especially has collected every kind of evidence together that seems to support it in his latest, and most admirable work, "Island Life." By a process of reasoning, supported by a large array of facts of different kinds, he arrives at the conclusion that the distribution of life upon the land, as we now see it, has been accomplished without the aid of important changes in the relative positions of continents and seas. Yet if we accept his views, we must believe that Asia and Africa, Madagascar and Africa, New Zealand and Australia, Europe and America, have been united at some period not remote geologically, and that seas to the depth of 1000 fathoms have been bridged over; but we must treat as "utterly gratuitous, and entirely opposed to all the evidences at our command," the supposition that temperate Europe and temperate America, Australia and South America, have ever been connected, except by way of the Arctic or Antarctic Circles, and that—lands now separated by seas of more than 1000 fathoms depth have ever been united.

Mr. Wallace, it must be admitted, has succeeded in explaining the chief features of existing life distribution, without bridging the Atlantic or the Pacific, except towards the Poles, yet I cannot help thinking that some of the facts might perhaps be more easily explained by admitting the former existence of the connexion between the coast of Chili and Polynesia and Great Britain and Florida, shadowed by the sub-marine banks which stretch between them. Nothing is urged that renders these more direct connexions impossible, and no physical reason is advanced why the floor of the Ocean should not be upheaved from any depth. The route by which the floras of South America and Australia are supposed to have mingled is beset by almost insurmountable obstacles, and the apparently sudden arrival of a number of sub-tropical American plants in our Eocenes, necessitates a connexion more to the south than the present 1000-fathom line. Again, the geological evidence, as I have pointed out in the Popular Science Review, is far from being so favourable to Mr. Wallace's view, as he supposed.

Apart from the regions of less depth, which I think may have been more or less land during the Tertiary period, there is some reason to believe in the general permanence of the Oceans over the areas where they are now deepest. It is perfectly certain that the causes which lead to elevation and subsidence must react upon each other, and if these were exclusively the result of shrinkage, there would be no reason why the sea-bottom at the greatest depths should not have come to the surface. *With a layer fluid under a given pressure, resting upon solid, and sensitive to any increase or decrease of pressure, the chief effects of elevation and subsidence could be explained.*[1]

Many persons have been struck with the almost universal tendency to depression exhibited in areas occupied by deltas and estuaries. This fact has frequently been alluded to in the GEOLOGICAL MAGAZINE, and elsewhere, and has been most clearly expressed by Dr. Charles Ricketts,[2] that this subsidence is directly produced by the accumulation of sediment. However insignificant, some cause must initiate movement in the earth's crust, and as an incautious shout may bring down an avalanche, so even an accumulation of a few feet of clay over several square miles may create a disturbing re-adjustment, and eventually lead to a downward tendency. Supposing a sediment, 50 feet in depth and entirely submerged, to have displaced an equivalent of sea-water, we should have an increased pressure per square yard (taking the mean density of the materials composing a delta at 170 lbs. per cubic foot) of rather more than 25,000 lbs., or about 34,848,000 tons per square mile. When we see that deltas have accumulated to depths of perhaps even beyond 1000 feet, and extend, as in the Mississippi, to 19,450 square miles, it is easy to realize how vast a force is present.[3]

The hypothesis that added weight leads to subsidence may also to some extent be sustained by the continuous depression of Coral Islands. Great accumulations of ice in the Glacial period seem to have been accompanied by subsidence, and even Greenland at the present day may be sinking under its ice-cap.

To apply the theory to a wider field, we frequently observe signs of subsidence on the sea-coast. We meet on every shore with vestiges of submerged land vegetation and with traditions of submergence since historic times. Though raised beaches exist, it should be remembered that these are local and always rendered conspicuous, while depressed beaches seldom or never attract attention. Forests have been depressed beneath the sea-level and no trace of them has ever come to light, except at low spring-tides and in

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[1] According to Lyell, all known rocks would fuse under a pressure of from 20 to 25 miles, whilst greater pressure would reconvert them to solids with a high specific gravity.

[2] GEOL. MAG. 1872, Vol. IX. p. 119.

[3] See Permanence of Continents, J. S. Gardner, Popular Science Review, 1881, p. 125.

exceptionally rough weather. We have generally to trust to foundations and well-borings near the coast, and these, as far as I am acquainted with them, have invariably shown that our sea-shores are steadily sinking. If this were not so, our land would be surrounded by extensive shoals of uniform depth, for the whole of the sediments from the wasting of the shore are thrown down almost entirely upon a belt 30 miles wide. The moving power of waves is not felt to a greater depth than forty feet, tides appear to have no permanent action in removing sediment, and shore currents of sufficient power are local and merely cut channel-ways. The rapidity with which silt accumulates may be seen by the manner in which wrecks become lost to view, and in the discolouration of the sea during rough weather produced by particles from the shore held in suspension. This shore deposit does not find its way to the depths of the ocean, and if its constant accumulation is not balanced by subsidence, what becomes of it?[1] A glance moreover at any stratified rock composed of littoral deposits, will show from its thickness, which often exceeds the depth of water in which it is supposed to have been deposited, that it must have been deposited in a subsiding area. No conclusion but this can be drawn in working through our Eocenes, and it is sufficiently obvious that no thick littoral deposit can take place in an area of elevation.

If the theory that sedimentation directly causes subsidence is pushed still further, we discover a physical reason for the permanence of Ocean basins. If permanent, deposition must have been continuous since Palæozoic times, and would to a large extent have filled in even the very greatest depths of the ocean, unless compensated by constant and gradual depression. The mean of four experiments made on the "Challenger" Expedition, determined the quantity of carbonate of lime in the form of living organisms in the surface waters to be 2·545 grammes, so that if these animals were equally abundant in all depths down to 100 fathoms, it would give 16 tons of carbonate of lime to each square mile of 100 fathoms depth.[2] There is no reason, however, why organisms contributory to sediment should not extend to, and even become more abundant towards the bottom. In the absence of knowledge as to the duration of life in such minute marine organisms as Globigerina, we are without data for estimating the rate of deposition in deep seas. Although at great depths shells of Foraminifera are reduced to bicarbonate, this does not seem to result in loss of material, for the samples of deep sea-bottom that have been dredged, and our own Chalk formation, tend to show that the supply of lime is not kept up to any extent by the dissolution of dead organisms.

The continuously increasing weight of sediment and of water

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[1] Sir J. Herschel was of opinion that the weight of sediment displaced by the sea produced elevation and depression along coast-lines (Phys. Geogr. p. 116).

[2] This would deposit, if replenished annually, one inch of sediment in 8,000 years. If life extended equally to 2,000 fathoms, one inch would be produced in 400 years. If 12 generations were produced per annum, one inch would result in 33 years, and this might be more than doubled by the decay of life at the bottom.

must exercise enormous pressure, tending to make the *greatest depths* of the sea permanent, and to continually elevate lines of least resistance into ridges or banks, resulting, where the state of tension is extreme, in isolated volcanic outbursts. The lines of absolute least resistance would probably, however, more generally coincide with sea-margins, because these would be the nearest lines to the area of depression, free from accumulating sediment. Upon coasts, therefore, while we might expect, and actually find, a tendency to local depression, owing, as I suggest, to littoral sedimentation; at a few miles inland there should be found a far more important and preponderating tendency to elevation.

That such a tendency has really existed is apparent from the positions of the chief mountain chains. Considering the very different distribution of seas which prevailed during the periods of elevation of some mountain chains, and the complicated forces at work, it is remarkable how the chief mountains of the world follow the existing, or recently existing coast-lines. In Europe we have the Icelandic mountains on its southern shores, and formed probably when Iceland extended some way north. The Norwegian chain, and the Welsh and Irish mountains follow the coast-line, and were chiefly formed perhaps, when England and Scotland were united to the Continent. The Sierra Nevada, the Cantabrian mountains and the Pyrenees; the Corsican, Sardinian and Sicilian mountains, the Apennines, Maritime and Dinaric Alps, and the Alps themselves, were formed when Eocene seas washed their bases. In Asia we find the Mediterranean, the Red Sea, the Gulf of Aden, the Persian Gulf, and the south shore of the Caspian, margined by mountains. Both sea-boards of Hindustan are followed a little way inland by the Eastern and Western Ghauts, and the Himalayas skirted the sea at the time of their formation. The Malay peninsula is a mountain ridge, and mountains follow the sinuosities of the Eastern coast of Asia from Singapore to Behring's Straits. Eastern and Western Australia also have their coast ranges.

In Northern Africa there are almost continuous mountains from the south of Morocco to Suez. The Kong mountains follow the coast of Liberia to the Slave Coast. The Cape mountains stretch north at least to Mozambique, and hills seem to line the coast from Zanzibar and meet the northern range at Suez. In America a magnificent range follows the Western coast from Alaska to Cape Horn, and on the east are the Alleghany and Rio de Janeiro mountains. Unless we believe that the principal chains of mountains follow present or past coast-lines by a mere coincidence, we must recognize that some definite law is at work.

But even more conclusive evidence is derived from the position of active volcanos, for these prove that the fluid layer is actually forced nearest to the surface along coast-lines. The Pacific is almost encircled by a marvellous chain of volcanic vents; and earthquake regions are also generally in proximity to the sea.

If the sedimentation going on annually at the bottom of the ocean really produces depression, that is, displacement of the fluid layer, it must force up mountain chains along lines of least resistance. The sustained pressure would continually keep fresh layers of the solid interior or of its own material at the liquefying point, and press them out in turn—imperceptibly deepening the ocean basins where they are deepest and raising the shallower parts to higher levels, thereby slowly lessening the surface area of seas. On the other hand, the dry land would extend in a corresponding degree, and its surface become more diversified, for new mountain chains would perhaps in succeeding ages have a tendency to reach greater elevations. Geology itself supports this hypothesis. The records of the Palæozoic rocks point to a comparative uniformity in the earth's surface in remote times, there being neither evidence of great depths in the sea, nor of mountainous elevations in the land, and palæontological evidence shows these conditions to have been progressively modified until the present day. If mountain chains and volcanic outbursts were caused only by the cooling of the earth, we should find, instead of the uniformly shallow sea of the older Palæozoic rocks—and the almost uniformly level land of the Carboniferous—evidence of even greater inequalities of surface than now exist.

While therefore upon this theory the *greatest depths* of the ocean may always have been permanent, the banks and ridges of less depth with islands occasionally rising to the surface, and crossing the Atlantic and Pacific, must either be rising or sinking. If they do not mean changes of level in the sea-bottom, whether of past or present elevation, what do they mean? Forces are unceasingly acting, and there is no reason why an elevating force once set in action in the centre of an ocean should cease to act until a continent is formed. They have acted and lifted out from the sea, in comparatively recent geological time, the loftiest mountains on earth. Mr. Wallace himself admits repeatedly that sea-beds have been elevated 1000 fathoms, and islands have risen up from depths of 3000 fathoms; and to suppose that the upheaving forces are limited in power is, it seems to me, to again quote from Island Life, "utterly gratuitous, and entirely opposed to all the evidences at our command."

In conclusion, I will only add that these ideas are obviously put forward tentatively, and await further proof or disproof. I propose next month to make the subject clearer by means of a diagram.

II.—The Classification of the Cambrian and Silurian Rocks.

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

A PAPER by M. Barrande, which has been recently published,[1] seems to call for some reply. M. Barrande, whilst working out the succession in Bohemia, adopted Sir R. I. Murchison's name "Silurian," and even applied it to lower rocks than did ever

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[1] "Du Maintien de la Nomenclature établie par M. Murchison, par M. J. Barrande," Extrait du Compte Rendu Sténographique du Congrès International de Géologie, tenu à Paris du 29 au 31 août et du 2 au 4 Septembre, 1878.

Murchison himself, and in the paper under consideration he supports this classification.

It may seem presumptuous to question the adoption of this classification by the great expositor of the Bohemian basin, but I would submit that it is not sufficient to judge of the merits or demerits of an historical classification, from its application to an isolated area, apart from the classical one, but it should be ascertained whether it can be applied over much larger tracts of country.

M. Barrande first expresses a regret that Murchison and Sedgwick studied only stratigraphical geology, and neglected palæontology, and attributes to this cause the confusion which has arisen. But not only had these two geologists considerable knowledge of palæontology themselves, but they also employed palæontologists of the first rank to assist them in their labours. Moreover, so far from the confusion having arisen from palæontological errors, it arose from mistakes in stratigraphy, in which the Woodwardian Professor had no part; it would be presumption on my part to enter further into this personal question, after the masterly essays of Sedgwick in the prefaces to "British Palæozoic Rocks and Fossils," and "A Catalogue of Cambrian and Silurian Fossils," and the able defence of Sterry Hunt, reprinted in his "Chemical and Geological Essays."

M. Barrande then goes on to state that the three faunas which he names primordial, second, and third, can be traced over very wide areas, whereas the smaller subdivisions (*étages*) have no exact parallelism in different countries. This is to a certain extent true of deposits formed in shallow water, but the black muds which indicate deep-water conditions are very widely spread. I may cite as an instance of this the occurrence of the Arenig fauna in countries as widely separated as Britain, Sweden, Bohemia, France, and Spain.

The characteristics given of the three faunas admit of so many exceptions, as to be of very doubtful classificatory value. The primordial fauna is said to be composed almost entirely of Trilobites: this may be the case where the deposits are of a deep-sea character; but whenever indications of shallow water occur, Brachiopods abound, *e.g.* in the Lingula Flags of Britain, the Olenus beds of Scandinavia, where *Orthis* is very abundant in the calcareous beds,[1] and in a paper read before the Geological Society, June 9th, 1880, I gave reasons for supposing certain grits of Bohemia, crowded with *Lingula Feistmanteli*, to be the equivalents of the Lingula Flags of Britain.

"In the second place these primordial Trilobites are characterized by their conformation," the head is small, the thorax large, and the tail scanty (*exigu*); this scantiness is explained as not referring to the extent of the tail, but to the small number of segments of which it is composed. In reply to this I may remark that the tails of such genera of the second and third faunas as *Remopleurides*, *Acidaspis*, and various genera of the *Cheiruridæ* are strictly comparable to those of *Paradoxides*, etc., of the primordial fauna.

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[1] Cf. Linnarsson, Bihang till K. Svenska Vet. Akad. Handl. Band 3, No. 12.

The second fauna is described as possessing Trilobites which contrast with those of the primordial group; either the head, thorax, and tail are pretty nearly in equilibrium, as in *Asaphus*, or the thorax is reduced, and the head and tail developed, as in *Illænus*. But *Illænus* possesses no segments to the pygidium, and this is the case with the primordial *Microdiscus* and *Agnostus*, which also have a reduced thorax. Lastly there are several Trilobites of the second fauna, comparable with others of the primordial, such as *Calymene* with *Conocoryphe*, and *Harpes* with *Erinnys*, and the tails of these do not possess very many segments, and are quite disproportional to the thorax in their size, and the number of segments.

M. Barrande believes that the second fauna is also characterized by fossils which have never been found in the preceding fauna. These are chiefly Cephalopods and Lamellibranchs. But the occurrence of an abundance of Cephalopods and Lamellibranchs in the earlier beds of the second fauna, *e.g.* in the Orthoceras Limestone of Sweden, and in the Tremadoc rocks of Ramsey Island, as shown by Dr. Hicks (Q.J.G.S. Feb. 1873), would indicate that they must have previously existed in the earlier fauna; migration with certain physical conditions, as kindly suggested to me by Dr. Hicks, will account for their absence, so far as known, in the European area. In short we may object to the first of M. Barrande's arguments, that the primordial beds have not been yet studied over a sufficiently large area for us to say definitely that they are without Cephalopods or Lamellibranchs anywhere; in fact the evidence goes to point to the fact that they must have existed somewhere at this time. To the second argument we may object that characters which are hardly of generic value in the Trilobites[1] can scarcely be of much value as assisting the classification of large groups of beds, especially when there are so many exceptions to the rules laid down.

M. Barrande proceeds to point out that although in his opinion these three faunas are distinct, there exist nevertheless beds of passage between them in certain countries. Such he considers to be the Tremadoc rocks of England. In these beds he recognizes rare representatives of the primordial fauna, as *Conocoryphe* (*Conocephalites*) and *Olenus*, whilst with these appear Trilobites more characteristic of the second fauna, as *Niobe* and *Psilocephalus* or *Illænus*. In a paper on Bohemia, already referred to, I pointed out reasons for concluding that Band *D. d.* 1 *β*. of M. Barrande represented the Tremadoc rocks of England, and that among the scanty fauna obtained from it, there occurred the primordial *Harpides*, with *Amphion*, a Trilobite found in Barrande's second fauna. The beds of Hof, in Bavaria, described by M. Barrande as containing forms both of primordial and second faunas, also seem to be referable to the Tremadoc rocks. The Tremadoc rocks of Shropshire (cf. Callaway, Q.J.G.S. vol. xxxiii. p. 652) also have a fauna somewhat

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[1] Of the genus *Phacops*, the subgenus *Chasmops* has a large tail and many segments, the subgenera *Phacops* proper and *Acaste* have much smaller ones, and few segments relatively to the thorax.

intermediate between M. Barrande's first two faunas, especially after the light thrown upon the fossils of this group by Dr. Linnarsson (Geol. Mag. Decade II. Vol. V. p. 188).

The Tremadoc group is considered by M. Barrande as appertaining from its base to his second fauna. He states that unfortunately some English geologists have associated it with part of the true primordial fauna, in the subdivision which they name Upper Cambrian. If we analyze the list of Tremadoc fossils given in Salter's Catalogue of Cambrian and Silurian Fossils in the Woodwardian Museum, we find that of eleven genera, two are peculiar to the Tremadoc beds, one occurs both above and below, two occur *below* only, and six *above* only. This seems to bear out M. Barrande's view of the relation of this formation. Consequently those English geologists who have a tripartite division at present, ought to have a quadripartite one, or at any rate to shift their boundary-line in one case. But, indeed, we can draw hard palæontological lines between most of the groups of the so-called primordial beds in Britain, and I think that the explanation of this is evident. The primordial fauna of Bohemia is the representative of only one English formation, viz. the Menevian; when the so-called primordial group in Britain has been searched for fossils as carefully and persistently as that part of it in Bohemia which is fossiliferous, these breaks will disappear. In England our opportunities of collecting fossils are rarer than are those of foreign geologists; consequently we show a preference for working out the richer zones, and do not give so much time as would be desirable to the more barren intermediate beds.

Proceeding to consider the boundary between his second and third faunas, M. Barrande says that in the Llandovery group of England, which has been well studied, the inferior portion contains principally species of the second fauna, whilst the superior holds a majority of species of the third fauna. Our geologists now, however, usually group the Llandovery or May Hill Group entirely with the beds containing the upper fauna, whilst so far is our knowledge of these rocks from being complete, that there is still a great deal of confusion as to certain beds, whether they are of Upper Bala age, or belong to the lower part of the May Hill beds. I have in a recent paper (Q.J.G.S. 1880, p. 591) endeavoured to show that M. Barrande's "Colonies," which he appeals to as affording a mixture of the organisms of his second and third faunas, are to be explained as due entirely to physical disturbances.

M. Barrande states that Murchison's nomenclature is adopted by the Geological Society of London with the consent of nearly all European geologists, and that the names "Primordial Silurian," "Lower Silurian," and "Upper Silurian," are employed in the last edition of "Siluria," a classic work which is in the hands of all geologists upon both continents. The amount of agreement with regard to this classification is shown in the following table, partly compiled from the list in Salter's Catalogue of Cambrian and Silurian Fossils in the Woodwardian Museum:

	Sedgwick.	Murchison. 1868	Jukes. 1863	Lyell. 1871. Hicks.	Phillips. 1853	Geological Survey. 1865	Lapworth. 1879	Ramsay. 1878
LUDLOW	SILURIAN.	UPPER SILURIAN.	UPPER SILURIAN.	UPPER SILURIAN.	UPPER SILURIAN.	UPPER SILURIAN.	SILURIAN.	SILURIAN.
WENLOCK								
UPPER MAY HILL								
LOWER MAY HILL		LOWER SILURIAN.	LOWER SILURIAN, OR CAMBRO-SILURIAN.		LOWER SILURIAN.	LOWER SILURIAN.		
BALA (Upper, Middle, Lower (or Llandeilo).	CAMBRIAN.			LOWER SILURIAN.			ORDOVICIAN.	
ARENIG					CAMBRIAN.			
TREMADOC				CAMBRIAN.			CAMBRIAN.	
LINGULA FLAGS ...		Primordial. Silurian.						
MENEVIAN								
HARLECH		Cambrian.	Cambrian			Cambrian.		

With this list before us, it is impossible to say that geologists are agreed with regard to one or another classification. Nor are foreign geologists at all agreed as to their nomenclature; for although they use the terms Silurian and Cambrian, they are used in various senses. In Sweden, for instance, the Lobiferus and Retiolites Beds, respectively representing the May Hill and part of the Wenlock of Britain (cf. Tornqvist, Öfversigt af K. Vetensk.-Akad. Förhandl. 1879, No. 2, p. 72), are by some authors classed as Lower Silurian. What nomenclature then are we to adopt? No classification depending on natural breaks is applicable over an enormously large area, for very obvious reasons, but yet the British names of other formations than the Cambrian and Silurian are very largely used by European and other geologists, when describing their own areas. Nor are these groupings comparable with one another as regards size; for example, the Pliocene cannot be compared in magnitude with the Carboniferous, and yet these names are used as of equal value in the lists of systems given in our text-books. In short, our present classification may be described as an *historical* one; such being the case, the names Cambrian and Silurian should be used in their historical sense, until our entire nomenclature is re-modelled, and hence the word Cambrian should include the rocks from the base of the Harlech Beds to the top of the Bala group, as defined by its historian Sedgwick. The term thus used is also *natural* to as great an extent as, if not greater than, that for any other system, for it seems that the movements which affected the northern hemisphere in the Old World were very widespread during the deposition of the old rocks; the beds deposited in deeper water can be traced continuously over very large areas, *e.g.* the Arenig beds occurring as black muds in Britain, Southern Sweden, France, Spain, and Bohemia, also the representatives of the Birkhill Shales and of the beds characterized by *Retiolites Geinitzianus;* consequently if these areas were contemporaneously submerged to some depth, it follows that the intermediate upheavals were also contemporaneous, and the greatest upheaval throughout Europe seems to have been after the end of the Bala period, so that even where the deposits were not actually raised above the water, as they were in many cases, there was deposition in very shallow water. This is the greatest upheaval in the European area which occurred throughout the periods between the deposition of the Harlech Beds and that of the Ludlow, and it is accompanied by a palæontological break. Other physical breaks are local, and seem to have been due, not to widespread upheavals, but to local volcanic action, and hence are of no classificatory value; such is the break at the base of the Coniston Limestone of the English Lake District, and that at the base of Étage D. of Bohemia.

English geologists are requested to bring their nomenclature before the International Commission for the Unification of Geological Nomenclature. A classification must therefore be adopted for our Lower Palæozoic rocks; let us then be consistent, and add the names Cambrian and Silurian in their historical sense to the remainder of our historical names, especially as by so doing we make the nearest possible approach to a natural nomenclature, and although late, do justice to the great work of one of our greatest geologists.

III.—THE MAMMOTH IN EUROPE.

By HENRY H. HOWORTH, F.S.A.

(*Continued from page* 205.)

IN France deposits of the same kind, such as those at Menchecourt, are familiar enough. To complete our merely illustrative list of examples, I would quote the vast deposits found in the offing of the Thames, and right away to the Dutch coast. Dr. Bree says that the bones occur in such quantities on the sea-bottom off Dunkirk that the sailors call it the Burying Ground (Leith Adams's Mem. on *Elephas primigenius*, p. 73).

The identity of conditions in Europe and Siberia is carried out in other details. The deposit in which the bones occur is in both a fresh-water one, consisting of marly clay and of gravel, and its contents are of the same class. We mentioned in a previous paper how Schmidt found the remains of the Mammoth mixed with land and fluviatile shells. This is precisely the character of the corresponding beds in Western Europe, only that in the latter, from the fact of their having been examined with much more critical care, the number of species of such shells recorded is very much greater.

The discovery of these fresh-water shells is so constant, and they are so exceedingly numerous in the beds containing Mammoths' remains, etc., that it is perfectly useless to enumerate in detail the localities where they have occurred. In Ireland, in the marl underlying the peat, with the *Megaceros*; in England, in various neighbourhoods with the so-called Pleistocene fauna; and in France, in beds of the same horizon. We are told that sixty-five species of such shells have been found at Menchecourt, thirty-three at Saint-Acheul, and eighteen at Saint-Roch. They have been found in the valley of the Saone, of the Somme, in Dauphiny, and the Jura. The Loess in the valley of the Rhine and its tributaries is very full of such shells; so are the similar deposits in the Vosges and the Black Forest.

In the 29th volume of the Bulletin of the French Geological Society, p. 332, will be found an account of similar deposits in the valley of the Danube, also containing shells of the same class. The fact is they may be said to be universally present in these beds. The great abundance of their remains prove that the conditions must have been singularly favourable for the development of such molluscs. They point the same moral as the similar shells found in Siberia.

The species, with the exception of a few to which I shall revert presently, are the same as those still found in the Western Palæarctic region. M. Daubrée says of the shells found in the Loess of the Rhine Valley that some species are very common, namely, *Succinea oblonga*, var. *elongata*, *Helix hispida*, *Pupa muscorum*, *Helix arbustorum*, *Clausilia parvula*, *Pupa columella*, *Pupa edentulata*, *Helix crystallina*, *Clausilia gracilis*, *Helix pulchella*, *Helix montana*, *Pupa dolium*, *Clausilia dubia*, *Pupa pygmæa*, *Bulimus lubricus*, and *Pupa secale*. Seven other species are very rare. Of the whole number only one, namely, *Limnea minuta*, is fluviatile, and of this only 28 individuals out of 200,000 specimens have been noted. The greater part of these species, says our author, still live in the country; the rest are so little different that they may be treated as mere varieties. Nearly all still live in cold damp climates, and some in the Alps as high as the limits of snow (Bull. Geol. Soc. of France, vol. xxiv. p. 490).

Heer, speaking of the same class of shells, refers to the twenty-one species found by Professor Mousson in the Gallen part of the Rhine Valley, and described by him in the Transactions of the Natural History Society of Zurich in 1856, says they still without exception occur in Eastern Switzerland, most of them in the valley of the Rhine or at the foot of the nearest mountain slopes. *Helix ruderata* is not now found in the plain, however, and only in the highest mountain region, that of the mountains of Glaris, Prättigau and the Senlis chain. *Helix sericea glabella* and *Helix arbustorum subalpina* also belong to the mountain region. *Helix strigella*, with a wide umbilicus, still occurs near Sargans, *and is peculiar to that district.* All the species except the four first named, says Heer, are either forest snails from the region of leafy trees, or species which prefer shady moist places. Inhabitants of dry sunny localities are wanting. . . . Speaking of the Loess of the Lower Rhine, he says of the numerous snails which have been collected in it, the species of shady moist localities certainly predominate, and with them are mixed certain forms (such as *Helix hispida*, *Helix ruderata*, and *Helix arbustorum subalpina*), which at present are met with only in high mountains, while no species occur which belong to warm sunny localities (Prim. World of Switzerland, vol. i. pp. 213 and 214).

M. Tournouér, in describing the similar mollusca from the tuffs of Moret in the valley of the Seine, says that thirty-five species in all were discovered. They must have lived in the recesses of moist woods attached to leaves, to tender herbaceous plants, and to rocks where water fell; some were probably brought down from a higher level by torrents. Of the thirty-five species just named, one half still live in the neighbourhood; of the rest, some, like the *Helix limbata*, belong to the sub-Pyrenean district of South-western France, others to the mountain districts of the Alps and Jura. Of this class are *Bulimus montanus*, *Clausilia dubia*, *Pomatia septem-spiralis*, etc.; some to Eastern Europe, as *Helix bidens*, *Clausilia pumila*, etc.; others again to Southern forms, as *Vitrina major*, *Zonites acies*, a *Helix*, like *Helix fruticum*, etc. Some kinds seem to be extinct, as *Succinea Joinvillensis*, *Cyclostoma lutetianum*, several forms of *Succinea*, *Zonites*, and *Clausilia*. The most common species at Moret are the *Helix arbustorum* and *nemoralis*, still found over all Central and Northern Europe. The whole class found here is singularly like the parallel class from Canstadt, in Wurtemberg, both deposits being marked by the peculiar forms *Helix bidens* and *Zonites acies*. They bespeak a diffusion of European species more uniform than prevails now, with a damp and more uniform climate than now prevails, and at Moret one with a somewhat higher mean temperature, more like that now prevailing on the southern flanks of the Alps, in Friouli, and Croatia, where alone are now found the great *Zonites* (*verticillus*, *croaticus*, etc.), the *Helix nemoralis*, *Helix arbustorum*, and *Helix bidens* (Report of the International Congress of Anthropology at Stockholm, pp. 104–106).

This evidence is assuredly coincident with that furnished by the fresh-water shells of the Siberian strata, in which Mammoths' remains occur, and especially by the remarkable fact that such a southern form as *Cyrena fluminalis* occurs there (see Belt on the Superficial Deposits of Siberia, Journal Geological Society, vol. xxx. p. 490, etc.).

These mollusca not only point to a mild climate but to one which was comparatively mild all the year round. For they could not migrate with the seasons nor could they survive an arctic temperature. The same conclusion is attested by the remains of plants.

Here I would quote a curious passage from an essay by Baer, entitled "De Fossilibus Mammalium Reliquiis," etc., in which he describes the discovery of a number of trunks of birch trees with bones of Mammoths. I will quote his own graphic words. "In ponendo fundamento domus, custodi noni emissarii canalis Brombergensis destinatae, repertum est sub turfa, 9 pedes alta, stratum arenae tenuis et huic incumbens, magnus arborum numerus cortice fere incolumi, necnon ossium maximorum farrago, quorum multa, e fossa extracta sunt. . . . Clar. Wutzke, e consiliis regiminis, qui canali huic fodiendo, praefuit, de hac re a me interrogatus dentes effossos, dentibus mammonteis omnino similes fuisse affirmavit. Memoratu dignissimum videtur *sceleton in sylva prostrata inventum esse, et quidem inter arbores,* quos plaga nostra et hodie gignit. Contendit vir laudatus quanquam lignum corruptum invenisset, ex cortice *Betulam albam* se agnovisse nec unum inter operarias fuisse qui non idem censisset. Quid strias fuscas, quibus praeter alias gaudet cortex betulinus, conspicuas observavit vir in his rebus peritissimus. Num ex relatio concludere eis elephantem primigenium in patria nostra, betuletis inhabitasse et ergo non tropicam temperiem expertum esse, an mavis casu quodam terrae superficiei commotiones Betulas cum reliquis Mammonteis ex antiquiore aevo superstitibus in maris fundo quem arena indicat commiscuisse" (*op. cit.* pp. 15 and 16).

Mammoths' remains were found associated with cones of the *Pinus sylvestris* at Sprottau, in Silesia (Quarterly Review, vol. cxiv. p. 378), but it is the evidence recently adduced by Heer and Saporta which is the most valuable. The former has written on the Plant Remains from the Quaternary deposits so rich in Mammoth remains at Canstadt in Wurtemberg and elsewhere, and the latter on the similar remains from Moret, in the valley of the Seine.

From the tuffs of Canstadt Professor Heer has succeeded in identifying 29 species of plants; these comprised a large oak with obtusely and widely lobate leaves, six inches broad, and oval acorns nearly twice as large as those of *Quercus pedunculata*; a poplar with large cordate leaves, with but faintly undulated leaves (*Populus Fraasii*, Heer); a walnut, like the American *Juglans nigra* and *cinerea;* and among the species still living there, the red fir, the white birch, the hazel and the sycamore, the white fir, aspen, silver poplar, pedunculated oak, hornbeam, elm, lime tree and spindle tree, the *Salix monandra, fragilis, aurita, siminalis,* and especially *Salix cinerea,* the *Cornus sanguinea,* the *Rhamnus frangula* and *catharticus,* the box, the *Vaccinium uliginosum,* the great manna grass (*Glyceria spectabilis*) the reed and the harts' tongue (*Scolopendrum officinale*). Except the extinct species and the box, all these plants now live in Wurtemberg; the sycamore is not found at Canstadt however, but in the mountains, and the whortleberry in the peat bogs. "On the whole," says Heer, "climatal conditions are implied in the flora of Canstadt similar to those now prevalent in the same locality." In old turbaries of Ivræa and in drift debris near Mur in Styria trunks of the Siberian pine (*Pinus cembra*) have been found, and near Schwerzenbach, in the Canton of Zurich, in drift loam, *Betula nana, Salix retusa, Salix reticulata, Salix polaris, Polygonum viviparum* and *Dryas octopetala* (Heer, *op. cit.* pp. 206-7). This more northern flora is perhaps due to the proximity of the Alps, or it perhaps belongs to a somewhat earlier period. It is very probable indeed that the white clay band above the Bovey Tracey Lignites, which was described by Professor Heer and others in the 152nd volume of the Philosophical Transactions, is of the same age as the brick-earths and white marls in which the Mammoth occurs. It is interesting to note that Professor Heer recovered from this clay leaves of the *Betula nana,* and of three species of *Salices* which he identified respectively with *Salix cinerea, Salix repens,* and *Salix ambigua.* The first of these points to Devonshire then having had a colder climate than now, it not being found south of Scotland; the evidence of the willow leaves, says Professor Heer, is the same, indicating that at this time Bovey was a cold peat moor. He remarks that *Salix cinerea* is one of the commonest species at Canstadt (*op. cit.* p. 1044).

M. Saporta's researches have been devoted to the French strata, and he communicated a most interesting paper to the Stockholm meeting of Anthropologists in 1874, on the flora of the tuffs of Moret in the Seine Valley, already referred to. The following plants have been found there: *Scolopendrium officinale, Corylus avellana, Salix cinerea, Salix fragilis, Populus canescens, Ficus carica, Fraxinus excelsior, Viburnum tinus, Hedera helix, Clematis vitalba, Taxus sempervirens, Acer pseudo-platanus, Euonymus Europæus, Euonymus latifolius, Cercis siliquastrum.* Of these fifteen species, five are not now found at Moret, namely, *Ficus carica, Viburnum tinus, Taxus sempervirens, Euonymus latifolius,* and *Cercis siliquastrum.*

The whole of the plants found at Moret are also found at Canstadt, except the *Cercis,* the *Viburnum,* and the *Ficus.* The co-existence of these species, says M. Saporta, proves very clearly that, notwithstanding the variations due to latitude, Europe from the Mediterranean to its central districts offered fewer contrasts, and was more uniform than it is now. A more equable climate, damp and clement, allowed the *Acer pseudo-platanus* and the fig to live associated together near Paris, as it allowed the reindeer and hyæna. The

Acer grows with difficulty now where the *Ficus* grows wild, while the latter has to be protected in winter in the latitude of Paris (*op. cit.* pp. 102, 104).

In this debris of the flora we not only have a capital means of fixing the isothermals of the period when, and the district where, the Mammoth and his companions lived, but also have no doubt a fair list of the plants upon which he was accustomed to feed.

The evidence of the animals found with the Mammoth in Western Europe and Siberia points to precisely the same conclusion. Unfortunately we have had only very incomplete researches in the latter area, but we know that the *Rhinoceros tichorhinus*, *Bison priscus*, *Bos primigenius*, *Equus caballus*, and the *Ovibos moschatus* occur there, and all these occur together in the west; but further we find in these deposits in the west several animals which are still living in Siberia, and which have no doubt survived from the epoch of the Mammoth, but are no longer found living in Europe, such as the Saiga Antelope, the Reindeer, the Lemming, two species of *Spermophilus*, etc. The presence of these animals in both areas points most forcibly to the climatic and other conditions having been alike in both, a view which is much confirmed by the famous discovery described by Mr. John Evans, in the 20th volume of the Journal of the Geological Society, of not only bones of the wild goose which have occurred elsewhere in Europe, but also of portions of egg-shells, in all probability belonging to the same bird, which still breeds in such enormous numbers in Siberia. The immense deposits of fluviatile mollusca from the beds we have described prove what a famous feeding ground Europe must then have been for the wild goose, and shows why Europe should then have been its breeding quarters, it being widely held now that the summer habitat of birds is mainly fixed by abundance of suitable food.

While the evidence of the Mammals is satisfactory that a continuous climate and conditions ranged over both Siberia and Europe, their evidence is also consistent with that of the other factors we have adduced, that the climate must have been a temperate, and doubtless one with a more equable mean between summer and winter, marked perhaps by an isotherm very like the one which now characterizes Central Europe. This is surely pointed by the discovery of bones of *Lepus timidus*, near Salisbury, described by Mr. Evans in the paper already cited, and the more important discovery of remains of the *Sorex araneus*, of *young* moles, of the *Lepus timidus*, of the common squirrel, of the *Mus terrestris*, and of many bones of frogs, together with those of the Mammoth, Rhinoceros, and Hyæna, at Kostritz (see Schlotheim zur Petrefactenkunde, Gotha, 1822).

It would seem, therefore, that Siberia and Europe during the period of the Mammoth formed one zoological province, which in Western Europe more or less overlapped with an entirely different province then occupying the Mediterranean border-land, and of which some sporadic elements, such as the Hippopotamus, the *Rhinoceros leptorhinus*, and probably the *Machairodus*, extended into Mid-Britain. These mammals are matched among the mollusca by large specimens of *Cyclostoma elegans*, like those found in Northern Italy, the *Cyrena fluminalis* now living in the zone from the Caspian to Syria, larger specimens of *Helix arbustorum*, also pointing to a higher temperature, and *Vitrina elongata*, now living in the South of France, and these again by such plants as the *Ficus carica*.

The conclusion from these various facts seems inevitable that just as the companions and the various conditions of life which surrounded the Mammoth in Europe were the same as those in Siberia, so its mode of life was the same. That it lived and died where its remains are now found in a climate marked by a temperate character all the year round, and further that the causes of its disappearance were probably the same in both. The consideration of this last very critical question I propose, with the permission of the Editors, to postpone to another paper. I ought to state that this paper was written some time before the publication and entirely independent of Mr. Geikie's very admirable work on "Prehistoric Europe."

IV.—Notes on the Vertebrata of the Pre-Glacial Forest Bed Series of the East of England.

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

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PART IV.—RODENTIA AND INSECTIVORA.

As in the previous notes (Geol. Mag. Decade II. Vol. VII. No. 10, p. 447, 1880), so in the present, it is deemed desirable to give in the first instance a complete list of all the examples of the groups under consideration, which have hitherto been recorded, and then, having examined each critically, finally to give a corrected list.

Rodentia and Insectivora said to have been found in the "Forest Bed Series." (See also corrected list, at p. 259.)

Trogontherium Cuvieri.
Castor fiber (= *C. Europæus*).
Arvicola amphibia.
——— *agrestis.*
——— *arvalis.*
——— *glareolus.*
Sciurus, sp.
Mus musculus.
Talpa Europæa.
Sorex fodiens.
——— *remifer.*
Myogale moschata.

Rodentia.

Trogontherium.—In the year 1846, Prof. Owen referred certain lower jaws of a large Rodent, obtained from the Forest Bed, to Fisher's genus *Trogontherium*, with the specific name of *T. Cuvieri* (Brit. Foss. Mams. p. 184). Sir C. Lyell had already referred to these specimens in 1840 (London and Edinb. Phil. Mag. ser. 3, vol. xvi. p. 345), on Prof. Owen's authority, as belonging in all probability to a species of Beaver distinct from the recent one. English writers have, since the year 1846, almost without an exception, received Prof. Owen's determination; but on the Continent there has been great diversity of opinion, so much so, that the synonymy has become much too complicated for any attempt to be made to explain it in the present notes. It will be sufficient to say that in 1869 M. Gervais (Zool. et Paléont. General, p. 80), adopted M. Pomel's name of *Diabroticus Schmerlingii* for these large "Forest Bed" Beavers, believing that their affinity with Fisher's *Trogontherium* had not been established. Prof. Owen, however, in 1869 (Geol. Mag. Vol. VI. p. 49), described other specimens of these Rodents, and being still convinced that his previous determination was correct, retained the name of *Trogontherium Cuvieri.* Since that time several examples of upper- and lower-jaw teeth, with limb-bones, have been obtained, and it is with no little satisfaction I am able to say, that these confirm, in an unexpected manner, Prof. Owen's determination. Fisher's type specimen was a skull without the lower jaw and having the cheek teeth in an early stage of wear, so that each exhibited four folds or islands of enamel; the hindermost one having two small additional folds. The first British specimens found were lower jaws, so that it was extremely difficult to compare them, especially as neither of them had the teeth in the same early condition of wear as the type. The only upper jaw with teeth which was known, until quite recently, was that figured by Prof. Owen in 1869 (*loc. cit.*), and in this the only two teeth which were perfect had each only two folds, and consequently differed much from the original specimen. On this account several writers were of opinion that they could not be referred even to the same genus. An examination of the numerous teeth, both lower and upper, which are now to be found in various collections, show in a most conclusive manner, as it seems to me, that the folds of enamel, which in the early condition are all connected with the exterior surface of the crown, rapidly lose their connexion and become isolated, as is the case with most of the folds in Mr. Fisher's type. Gradually as the tooth wears some of the islands of enamel become obliterated, and hence in old examples some of the teeth may exhibit only two folds, as in the upper jaw figured by Prof. Owen and mentioned above. One series of upper teeth, in Mr. Savin's Collection, agrees as closely as possible with Fisher's original specimen as figured by Rouillier.

The great difference, which Prof. Owen maintained there existed, between this large "Forest Bed" Beaver and the recent forms of *Castor*, is likewise confirmed by recent acquisitions. Not only do these differences extend to the forms and proportions of the grinding teeth and incisors, both upper and lower, but also to the form of the lower jaw itself and to the bones of the limbs.

There is no evidence of a second species of *Trogontherium* from the "Forest Bed," all the remains at present found being referable to *T. Cuvieri.* These remains have been obtained at Cromer, Mundesley, Bacton, West Runton, and Kessingland, and Mr. R. Fitch has an incisor from the Norwich Crag of Thorpe.

Castor.—The remains of Beavers were among the earliest Mammalian bones obtained from the "Forest Bed," and were mentioned by S. Woodward in 1833 (Geol. Norfolk), and referred to *Castor fiber.* I have been unable to trace any remains of the true Beaver among the older specimens, except one tooth in the King Collection, and am inclined to think that most of the remains referred to as *Castor* were really *Trogontherium.* However, quite recently two or three undoubted examples have been found at West Runton and Kessingland, so that there is no question as to the occurrence of this genus in the "Forest Bed Series." I have preferred to retain Prof. Owen's name of *Castor Europæus*, seeing that good authorities acknowledge a constant, though slight, difference between this form and the American Beaver.

Arvicola.—The remains of Voles were recognized among the "Forest Bed" Mammalia as early as the year 1840 (Lyell, Lond. Edin. Phil. Mag. ser. 3, vol. xvi. p. 345). Prof. Owen seems to have been the first to refer any of them to the *Arvicola amphibia* (Brit. Foss. Mams. 1846, p. 205); and since then it has been included in most of the lists. Within the last few years remains of a smaller species have been found, and these have been referred by different writers to the species given in the list above. After a careful examination of a large series of Voles' remains, including, as I believe, all the important specimens hitherto found, I am led to the following conclusions: 1st. That of the larger forms of Vole found in the "Forest Bed," the greater number have well-developed fangs to the cheek teeth, in the adult condition, and on this account they cannot be referred to the common Vole, although the patterns of the teeth are almost identical in the two. I propose therefore to call this species *Arvicola* (*Evotomys*, Coues) *intermedia*, in reference to the intermediate position which it occupies between the *Arvicola amphibia* and *Arvicola* (*Evotomys*) *glareola.* 2nd. That it is doubtful whether the true *Arvicola amphibia* really occurs in the "Forest Bed." All the examples in the Green Collection which are referable to this species are from Ostend, and it is just possible that they were obtained from an alluvial deposit which is known to exist in the neighbourhood. Some few large specimens of teeth from West Runton have no fangs, and may possibly be *A. amphibia*, but the evidence is far from conclusive, and it seems best to put a query after the species. 3rd. That most of the smaller Voles are to be referred to *A. arvalis*, seeing that no example of the characteristic second upper tooth of *A. agrestis* has yet been obtained, while several examples of upper teeth with five angles have been found. 4th. One small lower jaw with fanged teeth, and several small teeth also with fangs, are definite evidence of the occurrence of *Arvicola* (*Evotomys*) *glareola.* Limb-bones of the larger and smaller species are also known.

Mus.—In the year 1869, Prof. Boyd Dawkins gave the *Mus musculus* as occurring in the Pre-Glacial Forest Bed (Quart. Journ. Geol. Soc. vol. xxv. p. 198), but there seems to have been some mistake about this specimen, as it has been omitted from each of the lists which he has published since that date. However, we are now in a position to re-insert the genus, although with a different species; for Messrs. C. Reid and A. Savin have each obtained a portion of a lower jaw with teeth, and both these agree precisely with the recent *Mus sylvaticus* both in size and in the arrangement of their cusps, and differ in both these respects from the *M. musculus*. These specimens were obtained from the West Runton Freshwater Bed, as were also certain limb-bones which probably belong to the same species.

Sciurus vulgaris?—It was Professor Oswald Heer, who first noticed that some of the Fir-cones found in the "Forest Bed" had been gnawed in a manner precisely like what is known to be the work of the recent squirrel, and on this authority Mr. A. Bell introduced the genus *Sciurus* into his list of Mammalia from these beds (Geol. Assoc. 1871). There is a small humerus from Ostend, in the Green Collection at the British Museum, which agrees so exactly with that of the recent *Sciurus vulgaris* that there is little doubt as to its belonging to that species. It is supposed to have been obtained from the "Forest Bed," but there is the same doubt as to its true horizon, as there was seen to be in the case of the *Arvicola amphibia*, and therefore, a query is placed after the species.

INSECTIVORA.

Talpa.—Since the publication of Green's History of Bacton, in 1842, the Mole has been recognized as belonging to the "Forest Bed" Fauna. The characteristic humerus has been very frequently obtained from the Freshwater Bed at West Runton and Bacton, and jaws from the latter place are referable to the *Talpa Europæa*, and not to the *T. cæca*.

Sorex.—Prof. Owen recognized two species of *Sorex* from the "Forest Bed," which he thought were probably *S. fodiens* and *S. remifer*. Little more can be said, at the present time, than that there are two species differing in size, and although it seems to be desirable to refer them to the *S. vulgaris* and *S. pygmæus*?, this change from the names given by Prof. Owen is probably chiefly owing to the complex synonymy of the species, which, in 1846, had not been so carefully worked out as it has since been by Blasius and Bell.

Myogale moschata.—The lower jaw called by Prof. Owen *Palæospalax magnus* is now known to be identical with that of the recent Desman of Russia, the *Myogale moschata*, which is referred by some writers to the genus *Sorex*. Several jaws and limb-bones have recently been obtained from West Runton, which confirm the identity of these fossils with the recent form.

LIST OF THE RODENTIA AND INSECTIVORA OF THE "FOREST BED SERIES," CORRECTED IN ACCORDANCE WITH THE ABOVE NOTES.

(Those marked with an asterisk * are new to the "Forest Bed Series.")

Trogontherium Cuvieri, Owen.
Castor Europæus, Owen.
Arvicola amphibia? Linn.
*——— *intermedia*, n. sp.
——— *arvalis*, Pall.
——— *glareola*, Schreb.

Sciurus vulgaris? Linn.
**Mus sylvaticus*, Linn.
Talpa Europæa, Linn.
Sorex vulgaris, Linn.
——— *pygmæus*, Pallas.
Myogale moschata, Linn.

V.—ON THE CORRELATION OF THE LOWER PALÆOZOIC ROCKS OF BRITAIN AND SCANDINAVIA.

By CHARLES LAPWORTH, F.G.S., etc.,
Professor of Geology and Mineralogy, Mason Science College, Birmingham.

IN the pages of the GEOL. MAG., about a year ago,[1] I called attention to the rapid growth of our knowledge of the sequence and fossils of the Lower Palæozoic Rocks of Sweden, through the brilliant discoveries of the officers of the Swedish Geological Survey; and pointed out what appeared to myself to be their special bearing upon certain controverted points in British Geology. During the past year the additional results obtained by the same group of earnest and unprejudiced observers are so important in themselves, and have been worked out with such care and elaboration, that we have now a tolerably complete view of the entire Lower Palæozoic Succession in the Scandinavian Peninsula, and are, for the first time, in a position to attempt the detailed correlation of its recognized rock groups with their representatives in Britain.

It is now at least some thirty-six years since Murchison made his first attempt to parallel the Scandinavian Succession with that worked out by himself in the West of England;[2] and more than fourteen years since he put the finishing touches to this parallel in the classic pages of "Siluria."[3] To those who have not attentively studied the recent advances in our knowledge of the Lower Palæozoic formations of Britain, Murchison's parallel still appears sufficient for all scientific purposes. But all earnest students of British Palæozoic geology are well aware, that although satisfactory enough in its day, it has long ceased to be of any practical value; while, at the present time, it has the positive disadvantage of hiding from geologists in general the many striking correspondences now known to exist between the Lower Palæozoic formations in Britain and Scandinavia. In the present memoir, therefore, I propose, while directing attention to the valuable data recently supplied us by the geologists of Sweden and Norway, to treat of these data in geological sequence, to indicate as briefly as possible, a few of the chief points of identity or similarity between the Lower Palæozoic formations as developed in Britain and Scandinavia, and to construct therefrom a new parallel that shall summarize our present knowledge, and afford the working geologist a general idea of the lines upon which his future investigations may most profitably be directed.

Section I.—CAMBRIAN SYSTEM.

Under the name Cambrian I include, with Dr. Hicks, all the fossiliferous strata lying between the basal beds of the Harlech Rocks as shown at St. Davids, and the provisional line drawn at present between the Lower and Upper Tremadoc Beds of Sedgwick

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[1] Lapworth, On Linnarsson's Recent Discoveries in Swedish Geology,—GEOLOGICAL MAGAZINE, 1880, pp. 29, 68, et. seqq.

[2] Murchison, Quart. Journ. Geol. Soc. vol. i. p. 467, 1845.

[3] Siluria, fourth edition, p. 348, et seq., 1867.

and Salter, as exhibited in the typical localities in North Wales. These limits define, with sufficient accuracy for our present purpose, the strata containing the *First* or *Primordial Fauna* of Barrande, as developed in Britain. In the rocks of this age, two distinct faunas have long been universally recognized—a younger subfauna marked by the preponderance of Trilobita of the genus *Olenus* and its most intimate allies, and an older subfauna individualized by the exclusive possession of the remarkable genus *Paradoxides*. Broadly speaking, the Olenidian (or *Olenus*-bearing) rocks constitute the Upper Cambrian of Hicks, and the Paradoxidian (or *Paradoxides*-bearing) his Lower Cambrian. But the genus *Paradoxides* has not hitherto been detected in the thick sandstones and flags that form the basal zones of Hicks' Lower Cambrian. These have, as yet, yielded little except the Annelide-burrows and markings (*Scolithus*, etc.) common in sandy deposits of all ages. It is certain that traces of more highly organized creatures will, in the future, be detected in these basal beds, but it will, in the mean time, be found most convenient, for purposes of comparison, to allude to these deep-seated zones as the *Annelidian* or Scolithian beds of the Cambrian.

Following generally the classification of the strata, containing the British Primordial Fauna, proposed by Dr. Hicks. we may, at present, regard the typical Cambrian System of Wales as being composed of the following members :—

- (III.) *Upper Cambrian* of Hicks (*Olenidian Division*).
  - (4) Tremadoc (Lower) Group of Belt and Dr. Callaway, with *Asaphellus Homfrayi*, *Dictyonema sociale*, etc.
  - (3) Dolgelly Group of Belt, with *Parabolina spinulosa*, Wahl., *Peltura scarabeoides*, Wahl., etc.
  - (2) Festiniog Group of Belt, with *Conocoryphe macrura*.
  - (1) Maentwrog Group of Belt, with *Olenus gibbosus*, *Agnostus pisiformis*, Linn., etc.
- *Lower Cambrian* of Hicks (*Paradoxidian Division*, etc.).
  - (II.) Menevian Group of Hicks, with *Paradoxides Davidis*, Salt., etc.
  - (I.) Harlech Rocks of Hicks.
    - (1) Superior Group, with *Paradoxides*, *Plutonia*, etc.
    - (2) Inferior Group, with *Annelides*, *Lingulella*, etc. (*Annelidian Division*).

The great fossiliferous Cambrian System of Wales, as thus defined, is nearly three miles in vertical thickness, and reposes unconformably below, both at St. Davids[1] and in the Harlech Region,[2] upon the metamorphic rocks of the Archæan; while in both these areas its highest beds are surmounted with apparent conformity by the basal zones of the succeeding *Ordovian* (or *Lower Silurian*) System, with a new and distinct fauna.

Cambrian System in Scandinavia.—Occupying a systematic position identical with that of the Welsh Cambrian, we find in Scandinavia, as the first of its Lower Palæozoic Systems, a corresponding series of fossiliferous sediments, marked by a similar fauna. As in Wales, also, this series is most conveniently regarded as being separable into two main divisions; a Lower Division of sandstones and greywackes resting unconformably upon the Archæan, and an Upper Division (the

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[1] Hicks, Quart. Journ. Geol. Soc. 1877, p. 238, etc.

[2] Hicks, GEOL. MAG. 1880, p. 529.

well-known *Alum Schists*) of calcareous and pyritous flagstones and shales, passing up conformably into the basal beds of the succeeding Ordovian System, with its distinct fauna. But, while in the typical British area of St. Davids, the Lower, or sandy division of the Cambrian, contains examples of the genus *Paradoxides* in all its higher zones, the homotaxeous arenaceous rocks of Scandinavia show no trace whatever of the presence of that conspicuous fossil. It is, however, present and abundantly prolific in the lower half of the succeeding *Alum Schist* division. Hence it has been contended by Linnarsson that the Alum Schists represent the whole of the British Trilobite-bearing Cambrians, and that the underlying sandy strata answer to the barren basal beds below. By Dr. Hicks, on the contrary, it was believed that none of the Alum Schists are of greater antiquity than his Menevian Group, and that the Swedish sandstones represent merely the highest zones of his arenaceous Harlech Rocks. For my own part, though I suspect that the deep-seated Annelide-bearing sandstones of the Cambrian in both regions are merely rapidly deposited arenaceous bases to the slowly accumulated Paradoxidian Rocks which overlie them, and thus of slightly different geological ages in different localities, I shall here conventionally group them together under the general title of *Annelidian* or *Scolithian*.

The Cambrian Rocks of Scandinavia have been subdivided as follows:

Sweden (Linnarsson, etc.).[1]

V.—Dictyonema Schists, with *Dictyonema flabelliforme*, Eichw.

IV.—Olenus Schists (Upper Alum Schists), with *Peltura scarabeoides*, etc , in the upper zones, and *Olenus gibbosus*, Wahl., and *Agnostus pisiformis*, Linn., in the lower.

III.—Paradoxides Schists (Lower Alum Schists), with *Paradoxides Forchhammeri* in the highest beds; *Par. Davidis*, Salt., and *P. Hicksii*, Salt., in the middle; and *Paradox. Kjerulfi*, Linrs., in the lower zones.

II.—Fucoid Sandstone, with Fucoids (Annelides) and *Lingulella ?*

I.—Eophyton Sandstone, with *Eophyton*, *Cruziana* (Annelides), and *Obolus ?*

Norway (Prof. Kjerulf).[2]

Primordial Formation (Kjerulf).

II.—Olenus Etage (Alum Schists), with *Dictyonema*, *Peltura scarabeoides*, Wahl., *Olenus gibbosus*, W., *Agnostus pisiformis*, Linn., etc.

I.—Paradoxides Etage—
- 1*d*. Upper Paradoxides Niveau, with *Paradoxides Forchammeri*, Ang.
- 1*c*. Middle Paradoxides Niveau, with *Paradoxides Tessini*, Brongn., etc.
- 1*b*. Lower Paradoxides Niveau, with *Paradoxides Kjerulfi*, Linrs., etc.
- 1*a*. Sparagmite formation, without fossils.[3]

Basal Cambrian Sandstones (*Annelidian*) *of Sweden.*—The Annelide-bearing Sandstones which lie at the base of the Cambrian System of Sweden are arranged by the officers of the Swedish Geological Survey in two main divisions—the *Eophyton Sandstone* and the *Fucoid Sandstone.* The first of these reposes, with a strong unconformability, upon the underlying Archæan, and is succeeded conformably by the second, which graduates conformably in its turn into the overlying Paradoxidian zones.

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[1] Linnarsson, Geol. Mag. 1876, p. 241, etc.

[2] Kjerulf, Die Geologie des Mittleren Norwegen (Bohn), 1880, p. 56, etc.

[3] Kjerulf, *ibid.* p. 145.

From the inferior or *Eophyton Sandstone*, Mr. Linnarsson has collected the enigmatical fossil which gives its name to the formation, the remarkable *Eophyton Linneanum*, together with a peculiar Brachiopodous shell (*Obolus? monilifer*, Linn.), forms of *Pteropoda* and *Sponges* (*Astylospongia*), and the so-called Annelides—*Cruziana*, *Arthrophycus*, etc.

The succeeding Fucoid Sandstones are comparatively barren, the only forms yet quoted from them are *Lingula? favosa*, Linrs., and the usual Fucoid tracks and burrows of worms, etc.

These sandstones are well developed in Westrogothia, Ostrogothia, Nerike, and Scania. In the last-mentioned region, the entire series occurs, according to Angelin and Dr. Lundgren, in four recognizable zones, with the following characters:[1]

(4.) *Greywacke Schists* (50 feet), containing occasional nodules of phosphorite, but no recognizable fossils.
(3.) *Hardeberga Sandstone* (600 feet), a coarse-grained hard sandstone with quartzose matrix, passing into greywackes in the upper zones, containing fucoid-markings and burrows of Annelides.
(2.) *Quartzite, and Quartzite Conglomerate* (150 to 200 feet), a thick hard rock, brittle, with conchoidal fracture.
(1.) *Lugnas Sandstone.* A coarse sandstone (60 feet), containing (crystals of) quartz, felspar, and mica—in other words, an *arkose*. According to Angelin himself, the lowest layers of this sandstone alternate with the bedded gneiss. According to Linnarsson, this relation is open to question.

If (as suggested by Lundgren) zones 3 and 4 represent the *Fucoid Sandstone*, that formation attains here a maximum thickness of 650 feet, and the basal or *Eophyton beds* a depth of 250 feet. The thickness of the same formations near Oland is estimated by Sjögren at 350 feet and 150 feet respectively.[2] In Westrogothia they have a collective thickness of from 70 to 80 feet.[3]

Alum Schist Formation of Sweden.

The Upper or Alum Schist formation of the Swedish Cambrian System attains its typical development in the classical locality of Andrarum in Scania, where its two grand divisions—the Lower characterized by *Paradoxides*, and the Upper by *Olenus*—are highly fossiliferous, and admit of such a minute examination *in situ*, that it has been found possible to subdivide them into several distinct palæontological zones, and to give a tolerably exact estimate of the vertical thickness and characteristic fossils of each.

Angelin, misled by the highly prolific nature of the *Paradoxides*-bearing limestone of this locality, originally assigned it a systematic position superior to that of the *Olenus*-bearing beds;[4] his regio *A.* (Olenorum), to which he referred the generality of the Primordial Beds of Scandinavia, being regarded by him as inferior to his regio *B.* (Conocorypharum), and being supposed to occur only at Andrarum and in the island of Bornholm. Linnarsson, from his studies in

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[1] Lundgren, text to Angelin's Geologisk Öfversigts-Karta öfver Skåne, pp. 12–18.

[2] Sjögren, Bidrag till Ölands Geologi. Ofvers. K. V. Förh. 1871, p. 675.

[3] Linnarsson, Vestergötlands Cambriska och Siluriska Bildningar Kongl. Svenska. Vet.-Akad. Handlingar, 1869, pp. 29, 55.

[4] Angelin, Palæontologica Scandinavica, pp. iii, iv.

Westrogothia, showed that the *Olenus*-bearing strata there actually overlay the beds with *Conocoryphe* and *Paradoxides*.[1] The same fact was also subsequently demonstrated for the typical Scanian localities by Dr. Nathorst,[2] whose contributions to this question, brief as they are, are already classical in the history of Swedish geology. The literature of the subject is already voluminous; and, as might have been anticipated, all the most valuable contributions are from the palæontological side. Chiefest of these are the memoirs of Mr. Linnarsson, the accomplished palæontologist of the Swedish Survey,[3] whose every paper is a model of laborious accuracy and cautious generalization; of Professor Torrel;[4] of Mr. Sjögren,[5] and others. Within the last few months the development of the fossiliferous Cambrian deposits of the typical locality of Andrarum has been summarized with great care by Dr. Sven. Tullberg, in the introductory part of his most valuable memoir upon the "Agnostus-species of the Cambrian succession of Andrarum."[6]

(*Paradoxidian Division*).—According to Linnarsson the *Paradoxides*-bearing strata of Sweden fall most naturally into six divisions, viz.—

6. Strata with *Agnostus lævigatus*, Dalman.
5. ,, ,, *Paradoxides Forchhammeri*, Angelin.
4. ,, ,, *Paradoxides ölandicus*, Sjögren.
3. ,, ,, *Paradoxides Davidis*, Salt.
2. ,, ,, *Paradoxides Tessini*, Brongn.
1. ,, ,, *Paradoxides Kjerulfi*, Linnrs.

With one exception (that of No. 4) all these zones are recognizable at Andrarum, and judging from the elaborate tables, figures, and notes given in Dr. Tullberg's recent memoir, they appear to have the following local characteristics:—

1. The lowest zone (*Paradoxides Kjerulfi* zone of Linnarsson) consists of about 20 feet of schists reposing at a small angle upon the basal sandstones of the region. Its deepest beds are greywacke-like schists, with *Paradoxides Kjerulfi*, Linnrs., forms of *Ellipsocephalus* and *Arionellus*, and *Lingulella Nathorsti*, Linn. Next follow phosphorite-bearing limestones and alum schists, with fragments of a *Paradoxides* resembling *P. Sjögreni*, Linnrs., and the zone is terminated by alum schists with *Agnostus atavus*, Tullberg.
2. The following zone (*Paradoxides Tessini* zone of Linnarsson, *P. Hicksii* zone of Torrel) has a total thickness of about 30 feet. It appears to be capable of subdivision into at least three subzones, viz.—

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[1] Linnarsson, Bidtrag till Vestergotlands geologi, O.K.Vet. Ak. 1868.

[2] Nathorst, Lagerfolgen Cambriska formations vid Andrarum, O.K V Ak. Förh. 1869; Kambriska och Siluriska lagren vid Kiviks Esperöd, etc., *ibid.* 1876.

[3] Compare Linnarsson, Vestergötlands Cambriska och Siluriska aflagringar K. Vet. Ak. Handl. 1869; Några försteningar från Sveriges "Primoirdialzon," O.K.V.A. Förh. 1872; Öfversigt Nerikes Öfvergångsbildningar, *ibid.* 1875; Brachiopoda of Paradoxides-beds of Sweden, *ibid.* 1876; Fauna i Kalken med Conocoryphe exsulans, Publications Swedish Geol. Survey, 1879; Fösteningarne in svenska lagren med *Peltura* och *Sphærophthalmus*, Geol. Förens. Förh. 1880, etc., etc.

[4] Torrel, Petrificata suecana formationis cambricæ, Lund, 1869-70.

[5] Sjögren, Anteckningar om Öland, Öfvers K.V.Ak. Förh. 1851; Bidrag Ölands Geologi, *ibid.* 1871; Några försteningar Ölands Kambriska lager, Geol. För. Förh. 1872, etc.

[6] Publications Swedish Geological Survey, 1880.

- *a.* *Exsulans Limestone* (or subzone of *Paradoxides palpebrosus*), consisting of five or six feet of bituminous limestone, marked by the rich fauna described in 1879 by Mr. Linnarsson,[1] of which the chief forms are: *Paradoxides Tessini*, Brongn., *P. Hicksii*, Salt. (var. *palpebrosus*), *Liostracus aculeatus*, Ang., *Conocoryphe exsulans*, Linn., *C. Dalmanni*, Ang., *Agnostus gibbus*, Linnrs., *A. fallax*, Linnrs., *Acrothele intermedia*, Linnrs., *Obolella sagittalis*, Salt., and forms of *Hyolithus* and *Lingulella*.[2]
- *b.* Subzone of *Paradoxides Hicksii*, Salt. (typicalis), consisting of from 12 to 16 feet of flaggy beds containing some survivors of the foregoing forms, together with *Conocoryphe Dalmanni* and *Liostracus Linnarssoni*.
- *c.* The terminal subzone consists of schists about ten feet in thickness, in which *Paradoxides Tessini* is still present, but in which we have no longer evidence of the existence of *Paradoxides Hicksii*. The remaining forms are species of *Agnostidæ* (chiefly *Agnostus rex*, Barr., *A. parvifrons*, Linrs., *Agnostus fallax*, Linrs.), and a form of *Microdiscus*.

3. The next twenty-five feet of strata may be roughly designated as the Zone of *Paradoxides Davidis*, though this species is only doubtfully present in the highest beds. The commonest fossils are *Agnostidæ*.
4. The *Paradoxides-Davidis* beds are capped immediately by some two or three feet of highly fossiliferous limestone—the well-known "Andrarum Limestone," or Zone of *Paradoxides Forchhammeri*. In addition to the characteristic species, it contains:—

   Paradoxides Loveni, Ang., *Agnostus glandiformis*, Ang., *Agnostus brevifrons*, Ang., *Agnostus aculeatus*, Ang., *Conocoryphe* sp., *Selenopleura brachymetopa*, Ang., *Hyolithus tenuistriatus*, Linrs., *Acrotreta socialis*, Seebh., *Obolella sagittalis*, Salt., *Acrothele coriacea*, Linrs., *Kutorgina cingulata*, Bell, etc,
5. The terminal zone of the *Paradoxidian* at this locality is marked by the presence of *Agnostus lævigatus*, Dalm., a form which occurs also in the underlying Andrarum Limestone. The beds of this zone are only about five feet in thickness, and are separated from the overlying Olenus-bearing rocks by a bed of Alum schist, about six feet in depth, wholly destitute of organic remains.

(*Olenidian Division*).—The Swedish geologists usually break up the fossiliferous strata that intervene between the summit of the Paradoxidian and the basal zone of the Ordovian (or Lower Silurian System) of Sweden into two chief subdivisions—a lower division of *Olenus schists* and an Upper Division of *Dictyonema schists*. In Scania the Dictyonema schists are not recognizable as a distinct group;[3] but they may possibly be represented by the highest Olenus-bearing beds of that region, which occasionally yield fragments of *Graptolithina*, possibly referable to the genus *Dictyonema*. In any case the Olenus beds and the Dictyonema Schists belong to one and the same systematic rock-group, which, like that of the corresponding Welsh Upper Lingula Flags, is easily distinguished palæontologically by its collective fauna from the Paradoxidian below, and the basal beds of the Ordovian above; and as the genus *Olenus* is most characteristic, and apparently occurs throughout the entire series, I shall here refer to the collective group as the *Olenidian* or Upper Cambrian.

According to Dr. Lundgren,[4] the Olenus-bearing strata of Scania contain the following recognizable zones:—

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[1] Linnarsson, Fauna af *Exsulans*-kalk., Publications Geol. Survey Sweden, Series 3, No. 35, 1879.

[2] Comp. Lapworth, GEOLOGICAL MAGAZINE, 1880.

[3] Linnarsson, GEOL. MAG. 1876, p. 42.

[4] Lundgren, Ueber Angelin's geol. Uebersichts-Karte von Schonen, Neuen Jahrbuch für Mineralogie, etc. 1878.

7. Zone of *Cyclognathus micropygus*, Linnrs.
6. ,, *Peltura scarabeoides*, Wahl.
5. ,, *Leptoplastus stenotus*.
4. ,, *Parabolina spinulosa*, Wahl.
3. ,, *Beyrichia Angelini*, Barr.
2. ,, *Olenus truncatus*, Bronn.
1. ,, *Olenus gibbosus*, Wahl.

(1, 2). In the typical section of Andrarum, the basal zones 1 and 2 appear to be only dubiously separable, judging from the carefully prepared section and tables of Dr. Tullberg.[1] They are unitedly about twenty feet in thickness, and contain throughout the well-known *Agnostus pisiformis* of Linnæus. The included species of *Olenus* (*O. truncatus*, Bronn, and *O. gibbosus*, Wahl., *O. attenuatus*) appear to occur together in the central horizons. (3.) The succeeding five feet of shale, with *Beyrichia Angelini*, Barr., *Agnostus cyclopyge*, Tullb., and forms of *Olenus* and *Ceratopyge*, may be assigned to the third zone. (4.) The fourth zone, distinguished by the possession of the remarkable *Parabolina spinulosa*, Wahl., is about ten feet in vertical extent. (5.) Zone 5 is about the same thickness, and is individualized by the presence of *Leptoplastus oratus*, *L. stenotus*, *Eurycare angustatum*, Ang., *E. camuricorne*, Ang., and a form of *Sphærophthalmus*. (6.) Zone 6 is one of the best-marked zones in the series. It appears to be about twelve feet in thickness, and is characterized by *Peltura scarabeoides*, *Agnostus trisectus*, Salt., *Ctenopyge pecten*, Salt., sp., *Ctenopyge bisulcata*, Phill., sp., etc. (The fossils of this zone have been recently described by Linnarsson in a valuable memoir that will be noticed later on.) (7.) Finally, we have a terminal zone about eight feet in thickness, containing *Cyclognathus micropygus*, Linn., and forms of *Acerocare* and *Orthis*.

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

NOTICES OF MEMOIRS.

I.—ADDRESS ON THE AGE AND RELATION OF THE SO-CALLED "FOREST-BED" OF THE NORFOLK AND SUFFOLK COAST.[2]

By J. H. BLAKE, Assoc.M.Inst.C.E., F.G.S.;
of H.M. Geological Survey of England and Wales;
President of the Norwich Geological Society.

AFTER referring to the many conflicting opinions expressed on the subject, Mr. Blake called attention to his paper "On the Age of the Mammalian Rootlet-bed at Kessingland," and continued as follows:—I stated it marked an horizon of considerable importance with respect to the correlation of the beds in Norfolk and Suffolk, and occurred at the upper part, or thereabouts, of what is generally known as the Cromer Pre-glacial Forest-bed Series, and beneath the Lower Glacial Series of Messrs. Wood and Harmer.[3] This line is a line of denudation, and indicates in places a true land-surface, proved by rootlets *in situ*, observed by myself at the extreme ends and in

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[1] Tullberg, Agnostus-Arterna vid Andrarum, pp. 8, 9, etc.

[2] Abridged from the Proceedings of the Norwich Geological Soc., vol. i. pp. 137–160.

[3] GEOL. MAG. Dec. II. Vol. IV. p. 299.

numerous intervening places. It is a divisional line that for many reasons, in my opinion, marks the boundary between the Pliocene beds and the Drift or Glacial formations.

Much black peat and compressed wood occasionally occur in places along this horizon; sometimes immediately lying on the surface of the rootlet-bed, at others lying in basin-shaped hollows scooped out of this same deposit, which in places contains freshwater shells and freshwater beds associated with it, such as the well-known *Unio*-beds, etc. Drifted wood and other vegetable matter occasionally occur in the formations above and below this line, in considerable quantities in certain localities, as at Bacton and elsewhere.

Again, Mammalian remains are to be found in abundance in this rootlet-bed, in some of its associated freshwater black-beds, and in the beds underlying, down to the chalk, but never (or hardly ever —never so far as my actual observations have gone) in any of the Bure Valley beds overlying. A few have been recorded as having been found at the base of the Bure Valley beds in some inland pit-sections around Norwich and other parts, immediately overlying the denuded surface of the Chillesford clay. These may have been derived from the beds beneath, or the denuded rootlet-bed, if it ever extended so far inland. However, the rule is, to find them where I have stated, and previous searchers and writers corroborate my investigations and remarks in this respect. To speak generally, this divisional line, which I consider marks the top of the Pliocene beds, occurs about midway between the base of the Cromer-Till (which, as a rule, is a very marked line) and the Chalk, or, more strictly speaking, a little nearer to the Chalk; and inasmuch as the greatest thickness of the beds between the Cromer-Till and the Chalk is seldom so much, and nowhere more than from about 26 to 30 feet (which is about the maximum thickness of them in some places in the neighbourhood of Sherringham and Runton), the Pliocene beds, or what remains of them, are consequently but about 13 to 15 feet in thickness, and rarely to be seen so much as that. . . . .

The nature of this rootlet-bed can be best studied at Kessingland, where it is well developed, and generally more or less exposed. It mostly consists of a stiff clay of a greenish-grey colour, sometimes mottled with brown; it contains white concretions ("race"), many scattered little black flints, and in places numerous mammalian remains, scattered throughout its mass, and averages from about 4 to 10 feet in thickness, sometimes forming a distinct homogeneous bed of clay, and sometimes containing indications of stratification with sand; thousands of rootlets have been observed by myself in it, in a vertical position as they grew. . . . .

The relation of this rootlet-bed to the beds beneath it is of especial interest, and can be best studied at the extreme ends, viz. at Kessingland and Weybourne, where the lower beds rise up. We will first deal with the Kessingland end. During my researches there, I have seen the extreme southern part of the cliff from the road to the flagstaff well exposed, that portion usually being hid by talus and blown-sand. The section exhibited was the rootlet-bed 4 feet in thickness, underlaid by 2 or 3 feet of buff-coloured pebbly sand, and that by 4 feet or more of laminated grey and reddish-brown clay, ferruginous in places and containing concretions, and also curious contortions in the lower part at the southern end, the total thickness not being shown. This laminated grey clay, with curious contortions in it, is precisely similar to that at the north end of Covehithe Cliff; and after going backwards and forwards from one cliff to the other, on several different occasions, I could not resist the conclusion that it was the extension of the same formation, designated the Chillesford beds. These Chillesford beds, consisting of laminated grey micaceous clay and buff-coloured sand, occur beneath the rootlet-bed in several places at the base of the cliff at Kessingland, and are exposed also on the foreshore after a scour of the beach. I had previously felt inclined to refer these laminated beds to the same age as those to be seen in the next cliff (Covehithe) to the south of it, but was determined to make a thorough investigation, and exhaust the evidence, as far as circumstances would permit, before stating my convictions. When these laminated beds are traced further south to Easton Bavent cliff, it is well known still lower beds come up, viz. the "Norwich Crag," underlying the Chillesford clay, and forming a slight anticlinal. Had a Forest-bed existed at the base of the Chillesford clay, as has sometimes been supposed, we should have anticipated seeing it come up here, but what we see is the "Norwich Crag."

Now we will go to the Weybourne end, and see what is revealed to us there. At about 300 yards to the east of the flagstaff, the following section was seen by myself and my colleague, Mr. Reid, who first pointed it out to me (I having previously requested him to keep a sharp look-out for rootlets along a certain horizon between the Chalk and Cromer Till). The section was a very clear exposure of a lenticular patch of the rootlet-bed immediately underlying the Contorted Drift or Lower Boulder-clay. I minutely examined the deposit, which measured 3 feet in thickness, and found it consisted of its usual character, being an unstratified greenish-grey clay, with numerous small black flints dispersed throughout its mass, and it contained rootlets in a vertical position as they grew. The lenticular patch rested on laminated grey clay, which was 4 or 5 feet thick; beneath which was a little buff-coloured sand, and then 3 feet of Norwich Crag, consisting of a mass of shells resting on the Chalk, the surface of which is very irregular here.

Thus, it will be seen, that the relation of the rootlet-bed to the beds beneath it, coincides at the extreme ends; and there is nothing to be seen anywhere between these two points to interfere with this relation of the beds; but, as they frequently occur on a lower horizon, the lowest beds are seldom well exposed. . . . . .

It is time now to inquire, where is the Forest-bed? I reply, I know of no other land-surface anywhere round the Norfolk and Suffolk coast, except the one I have described under the designation of the Rootlet-bed, on account of the rootlets *in sitû* marking the boundary-line, and having been the means of tracing the line.

During five years I have searched in vain for a stool of a tree *in sitû*; and the members of this Society are well aware of the result of the investigations of my colleague Mr. Reid, in the same direction, and also what Mr. Norton, F.G.S., has written on the same subject. If stools of trees ever have been seen *in sitû*, it is my firm conviction they were rooted on the same land-surface I have described. . . . .

The true stratigraphical position of the Rootlet-bed (frequently called a Forest-bed) is, however, of considerable geological interest. All the evidence, as shown by superposition, etc., in my opinion clearly points to the conclusion, that it immediately overlies the Chillesford clay. The Rootlet-bed in some cases apparently being a freshwater deposit, as at Corton and at Kessingland; sometimes forming a distinct and separate bed one stage more recent than the Chillesford clay, and sometimes apparently passing down into the Chillesford clay, forming, as it were, the uppermost portion of the same; at other times it is to be seen lying on a more or less denuded surface of the Chillesford clay, as at Weybourne. . . . .

Now we come to a very important part of the history of this so-called Forest-bed, viz. the true age of the mammalian remains, which are referred to the period of the "Forest-bed" or "Forest-bed Series," and which, as you are aware, are at the present time undergoing a very careful investigation by my colleague Mr. E. T. Newton, F.G.S. (Assistant Naturalist to the Geological Survey). In this analysis, it is all important to know where each specimen was actually found, and from what bed it was derived. If there is any doubt as to the relation of the beds, much confusion must necessarily ensue. Some writers, in giving a history of this so-called "Cromer Forest-bed," have inferred, that the animals whose remains we find round that coast *lived in a forest that existed in that very locality.* Nothing can be more erroneous, in my opinion, the facts being entirely against any such conclusion. Marine or estuarine conditions prevailed at the time, as proved by the numerous marine and estuarine shells, with occasionally a few freshwater intermixed, and in places alternating with the marine, which have been traced by my colleague Mr. Reid along the foreshore from Weybourne, where the formation rests on the Chalk, to Sidestrand, on the east of Cromer, a distance of about ten miles; and they reappear again in the lower part of the cliff, further south, at Easton Bavent, the intervening space lying now at too low a level for them to be observed. . . . The timber may have been derived from a forest; but the forest itself may have been situated miles away from where we now find the remains of it; and so likewise the Elephants, Hippopotamuses, Rhinoceroses, Deer, and other animals may have lived and died miles away from where we now find their scattered and commingled remains, intermixed in places with marine, freshwater, and a few land shells. The term Forest-bed can only be correctly applied to a bed forming a land-surface, and on which a forest grew. . . . . .

I use the term "Rootlet-bed" in contradistinction to "Forest-bed," inasmuch as up to the present time no reliable evidence of forest growth has been observed *in sitû* upon it, and also, as previously stated, because the rootlets have been the means of tracing the land-surface. The rootlets which mark the horizon are all similar in nature; but it has not yet been determined to what vegetable growth they belong;—it is to be hoped some botanist will come to our assistance. The surface was probably a marsh-land, all the evidence pointing to that conclusion, on which trees may or may not have grown,—*but not necessarily a forest.*

I would therefore draw attention to the fact, that portions of the land-surface, marked by the rootlets, have frequently been called the "Forest-bed." Prof. Prestwich considers the rootlets as evidence of the Forest-bed at Kessingland. Mr. Gunn, on an excursion of this Society on one occasion to Corton, alluded to the "Forest-bed" peeping out at the base of that cliff; which deposit, however, was this same Rootlet-bed. . . . .

After these more or less marine, estuarine and freshwater deposits became land, there was apparently a pause for some little time. Then came about the grand subsidence of the whole beneath the sea (as proved by the marine shells in the middle part of the Bure Valley Beds at Runton, overlying the Rootlet-bed, such as *Leda myalis* and *Mya truncata*, both with their valves united, etc. Also by the marine and estuarine shells—which have been sometimes *erroneously* called Crag—that overlie the rootlet-bed at Bacton, etc., etc.). Thus was apparently ushered in the Drift or Glacial period. During the earliest part of this subsidence, the Rootlet-bed (as might reasonably be imagined) was more or less denuded, together with the Chillesford Clay immediately underlying it; then, all the gravels, clays, loams and sands, forming the greater part of the cliffs and land of Norfolk and Suffolk, were piled up more than 150 feet in thickness in places over this old marshy land-surface, flattening and compressing the wood and other vegetable matter that were first scattered over it.[1] Eventually these deposits were upheaved, and the present configuration of the country brought about, with the assistance of subaerial agencies. But the remarkable fact relating to this upheaval is, that the old marshy land-surface, though more or less squeezed and twisted about, was brought up, for the most part, apparently to about the same level with respect to the sea, as it probably occupied when the vegetable matter grew on its surface.

As mentioned, with possibly a few trifling exceptions, all the mammalian remains are to be found buried beneath the more or less denuded surface of the Rootlet-bed and the Chillesford Clay. The formations, underlying this marked line of unconformity, being the "Rootlet-bed," with its associated freshwater-beds, the "Chillesford Clay," and the "Norwich Crag"; and in all these formations, mammalian remains with drifted wood are to be found.

Much unnecessary complication and confusion in the classification and nomenclature of these Pliocene or Pre-glacial beds, which occur around the Norfolk and Suffolk coast, has been caused by the term "Forest-bed Series," as introduced in the year 1870 by Mr. Gunn,[2] and to its assumed stratigraphical position. It is stated by him to consist of a triple subdivision, viz. "the Rootlet-bed," "Forest-bed," and "Soil of the Forest-bed"; which sequence of deposits, however,

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[1] Recently at East Dereham—situated in the middle of Norfolk—Glacial Drift deposits, 120 feet in thickness, have been proved by a well-boring to overlie the Chalk; the pre-glacial beds being absent. See Proc. Norwich Geol. Soc. vol. i. page 127.

[2] Quart. Journ. Geol. Soc. vol. xxvi. p. 553.

I contend—with all due deference—is merely hypothetical, inasmuch as it can nowhere be proved to exist. It, moreover, indicates no age whatever, beyond being placed in the published section in the Quarterly Journal[1] beneath the Chillesford Clay and Norwich Crag; which order of superposition can be demonstrated to be entirely erroneous! Consequently, it is not only desirable, but clearly imperative that a different classification and nomenclature should be adopted.

I therefore propose the following triple subdivision: viz. "the Rootlet-bed," with its associated freshwater beds, the "Chillesford Clay," and the "Norwich Crag." And if it is considered desirable to have a connected series—owing to the very intimate relation of the beds, and the comparatively short period of time involved—I would suggest that the term "Mammalian or Norwich Crag Series" should be adopted, to embrace the three subdivisions above mentioned. This simple classification, I contend, accords with the facts observed, and the nomenclature suggested is amply sufficient, in my opinion, to denote the whole of the remarkable pre-glacial deposits referred to; which together are seldom to be seen anywhere around the coast in direct superposition, more than about 15 feet in thickness.

II.—THE CONGERIA BEDS IN ITALY.[2]

THE Congeria beds were shown to exist in Tuscany, in 1860, by Professor Capellini, and since then both Professor C. Mayer and Professor Fuchs have called attention to their appearance in various parts of Italy, and much has been written upon it during the last few years as bearing upon the question as to where the division between Miocene and Pliocene should be made in Italy.

The Congeria beds were already many years ago compared with those in the Wallachia and the Crimea, and now the same strata are shown to exist from Bollène (S. France), through Italy, Austria, Hungary, and the south of Russia. These sulphur-gypsum beds or Congeria strata on both sides of the Apennines are now shown to contain similar fossils, and the formation as found near Leghorn, Ancona, and Bologna, is directly compared, and it is shown to be analogous with that of the Piedmont Modenese, Reggiano, and Sicily, and to represent the "Schlier" of the Vienna geologists, the marl of Wielicska and Wallachia, and perhaps in part the marl of Boom (Belgium), and the exact correspondence between the gypsum of Tuscany and that of the Romagne and the Marche, long known for its fossil flora, is now fully confirmed by means of the fossil fauna. Although the fossils distinctly prove the identical age, yet in almost each locality there are some found not common in others, and this is found to be the case in the Congeria beds of the neighbourhood of Castellina Marittima and the Aconitano.

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[1] Quart. Journ. Geol. Soc. vol. xxxii. p. 124.

[2] Gli Strati a Congerie e le marne compatte mioceniche dei dintorni di Ancona. By Professore Giovanni Capellini, Mem. Accad. Lincei, ser. 3a. vol iii. 1879.
Gli strati a Congerie e la formazione gessoso-solfifera nella provincia di Pisa e nei dintorni di Livorno. G. Capellini, Mem. Accad. dei Lincei, ser. 3, vol. 1880.

Both in Tuscany and in the Marche it is found that the facies of the fauna points to the lower part of the Congeria beds, and in so far the Congeria strata only in part corresponds with that of Austria and Hungary, the upper part as there known being absent in Italy. The lower group of the Miocene strata of the Leghorn mountains corresponds with the marls and sands of the *Cardita Jouanetti* beds of the Rhine, and if these are to be considered Upper Miocene, then the Middle and Lower Miocene are unrepresented in the province of Pisa, but well developed in Tuscany.

In the second paper this formation is shown to be very well developed in the hills south-east of Pisa, especially good sections being exposed in the valley of the Marmolajo, and between Parrana and Cologne, where the complete series can be examined resting on the Leithakalk, and at Limone and Uliveto there is a marl bed intercalated in the formation containing plants, fish, and fossil insects, by which means these beds and the Oeningen lacustrine formation are correlated.

The Lower Pliocene is considered to end with the marl containing *Pecten comitatus*, Font., which has also been called *P. denudatus* and *P. Fuchsii*, De Stef.; and immediately below this follows the Congeria (sulphur-gypsum) formation, and these Professor Capellini proposes to divide into (1) Cardium beds with *Melanopsis Bonelli*; (2) marl with *Cypris*; (3) marl with *Melanopsis impressa*; (4) limestone and serpentine conglomerate; (5) marl with *Melanopsis Bartolinii.*

These Congeria beds are superposed on the Sarmatian or Tripoli beds of the Leghorn mountains, which again rest on Tortonian or Leithakalk, considered by some as Upper Miocene, and by others as Middle Miocene, the latter being the division followed by Capellini.

Both papers are accompanied with several plates of the fossils found in these beds. A. W. W.

REVIEWS.

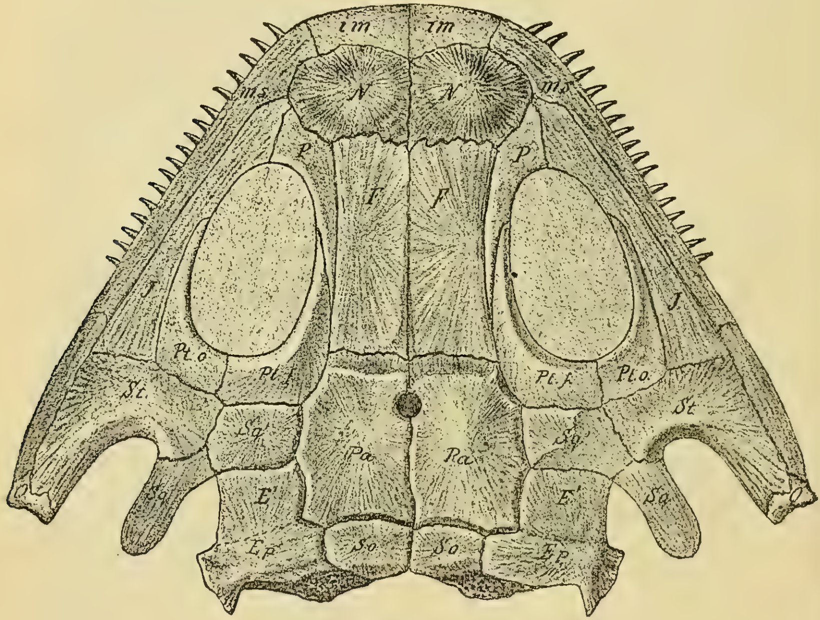
I.—Fritsch's Permian Amphibians of Bohemia.

THE second part of Dr. Fritsch's Monograph of the Fauna of the Permian Rocks of Bohemia fully sustains the interest of the first volume. It consists of 34 quarto pages of text, amply illustrated by many figures printed in the text, and by 12 coloured plates. It is impossible not to regard with admiration a work so fully and wisely illustrated; but equally in the literary work the author has endeavoured to give his labours completeness of expression, not so much with the object it may be of making the task of future labourers a sinecure, as in a happy endeavour to say everything that is worth knowing about his fossils. This memoir commences with some general remarks on the Branchiosauridæ, in which the opinion is expressed and sustained that several of the Stegocephali which have been described in other countries must be included in this family, so that the author finally arranges in it the following ten genera:—*Branchiosaurus* (Fr.), *Amphibamus* (Cope), *Pelion* (Cope), *Protriton* (Gaudry), *Pleuroneura* (Gaudry), *Sparodus* (Fr.), *Brachiderpeton* (H. and A.), *Hylerpeton* (Owen), *Dawsonia* (Fr.), *Hylonomus*? (Dawson).

The next family treated of is termed Apateonidæ, but the author finds all his specimens referable to a genus which is named *Melanerpeton.* This genus is defined as differing from *Branchiosaurus* in the form and proportions of the head and in its length relatively to the body, for while the head is between a third and a fourth of the length of the body in *Branchiosaurus*, it is here between a fourth and less than a fifth. The brain case has a similar posterior development to that seen in *Branchiosaurus*; the supratemporal bones are placed more anteriorly. The width of the vertebræ is to the length of the vertebral column as 1 to 8 in *Branchiosaurus*, while in *Melanerpeton* the proportion is 1 to 11 or 1 to 13. The sacral vertebræ enlarge and the ribs attached to them are modified in form. The ribs are short, and extend throughout the body, and are developed in the first five caudal vertebræ. The thoracic plates have a median stalk-like prolongation or interclavicular process. The abdominal armour was either absent or but faintly developed. Of this genus three species are described. The palæontological value of these presumed generic characters may perhaps require further consideration. *Melanerpeton pusillum* is estimated to have been 45 to 55 mm. long. The head, which did not exceed a centimètre, has been carefully restored; but the restoration wants the quadrate-jugal and quadrate bones. According to the figure, though I do not find any corresponding explanation in the text, the pre-frontal and supra-temporal bones are both blended with the jugal. The external or anterior nares appear to be in contact with each other, and occupy the middle line of the snout just behind the pre-maxillary bones. There are two small fontanelles about the size of the parietal foramen placed in the middle of the suture between the nasal and frontal bones; there also appears to have been a fontanelle in the middle of the suture between the supra-occipital bones. The maxillary bone contains 11 smooth small teeth. *Melanerpeton pulcherrimus* is a much larger species, having a length of 125 mm. The body is three times as long as the head. The skull is sub-triangular, being broad behind and relatively shorter than in *Melanerpeton pusillum.* The supra-temporal bone is deeply excavated behind. The surface structure of the skull bones is radiated. The author describes in detail the various elements of which it consists, but as the skull closely resembles that of *Branchiosaurus* (see Geol. Mag. Dec. II. Vol. VI. p. 524), it is unnecessary to describe it fully now.

Melanerpeton pusillum (Fritsch). Natural size. From the Permian Limestone of Ölberg near Brannau.

The skin in this species is naked, or shows no certain evidence of scales. The vertebral column is well ossified. There are 23 dorsal vertebræ; 1 sacral; and 16 caudal vertebræ, though 4 more were developed, making a total of 44. As in the allied forms the notochord persists. The transverse process is strong, and placed anteriorly. The hinder part of the vertebra is overlapped superiorly by the succeeding vertebra. The sacral vertebra is twice as wide as the last dorsal. The tail-vertebræ are much shorter than the thoracic vertebræ, and rapidly diminish in breadth. There are no ribs to the first five vertebræ, though they may have existed; and the last three dorsal vertebræ have the ribs short. The ribs in the tail are not so long as the vertebræ are wide. The shoulder girdle is strongly developed. The middle thoracic plate has a broad shield shape with a median hinder process. In front of it are the two clavicles, the lateral parts of which are thin and cylindrical. The coracoids are spoon-shaped, and the scapula like that of *Branchiosaurus.* The fore-foot is short. The humerus is four-sided, and as wide at the proximal end as it is long. There were five digits made up of very short phalanges. The femur is twice as long as wide, and, though longer than the humerus, is narrower. The



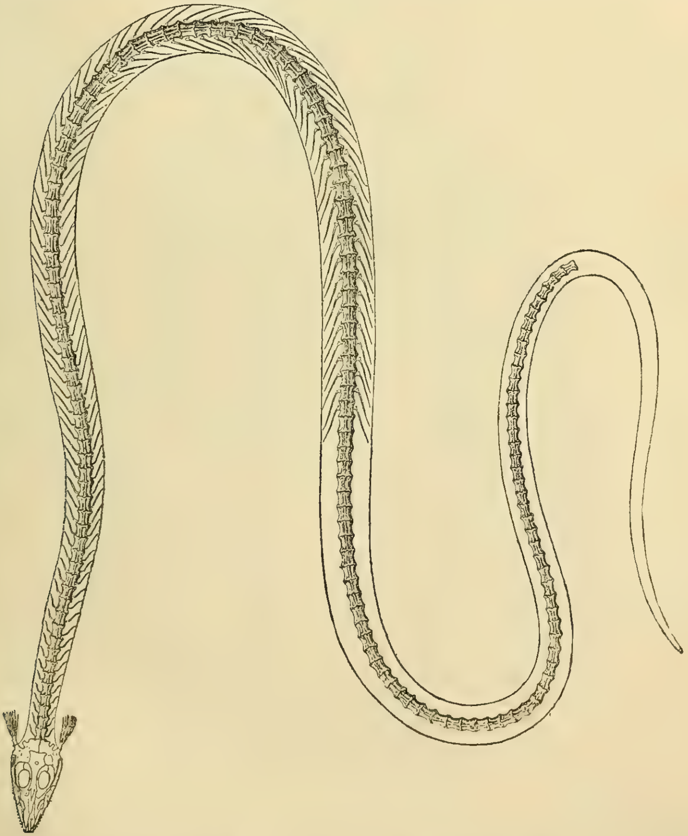
Melanerpeton pulcherrimum (Fritsch).

Upper side of the skull, restored; $3\frac{1}{2}$ times natural size. *im.* intermaxillary; *ms.* maxillary; *N.* nasal; *F.* frontal; *P.* prefrontal; *Ptf.* postfrontal; *Pto.* postorbital; *J.* jugal; *Pa.* parietal; *Sq.* squamosal; *Ep.* epiotic; *St.* supratemporal; *Q.* quadrate; *So.* supraoccipital.

fibula is rather more slender than the tibia. The metatarsals were well developed, and twice as long as the ends are wide.

Melanerpeton fallax (Fritsch) presents a very distinct form of skull, and I entertain but little doubt that it belongs to a distinct genus, which may be easily separated from *Melanerpeton*, not only by the skull-form, but by the skull structure. The outline is remarkably constricted posterior to the parietal foramen, anterior to which the shape is a broad blunt triangle. Between the broad pre-maxillary, oblong jugal and triangular pre-frontal a bone appears on the anterior margin of the orbit, which the author omits to name, but indicates by the letter *l*, that can only be the lachrymal. Post-frontal, post-orbital, and supra-temporal bones appear from the restoration to be blended together.

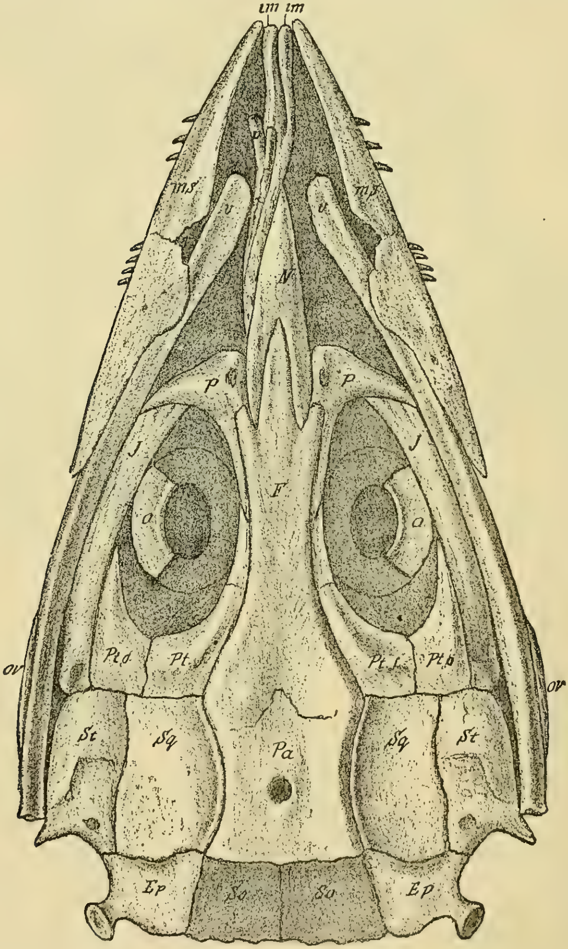
A few remarks follow on the relation of *Melanerpeton* to *Archegosaurus*.



Dolichosoma longissimum (Fr.), restoration half natural size. From the Coal of Nyřan.

The next family, Aistopoda, comprises snake-like animals devoid of limbs, with biconcave vertebræ, ribs, and smooth teeth. It is represented in Bohemia by the genera *Dolichosoma*, *Ophiderpeton*, *Palæosiren*, and *Adenoderma*. In *Dolichosoma* the skull is small; it tapers towards the snout. There are 150 biconcave vertebræ, with zygapophyses, and well-developed transverse processes.

Dolichosoma longissimum (Fritsch) is distinguished by having the ribs twice as long as the vertebræ. In form it closely resembles the whip-snake (*Dendrophis*). The fragment found measures 60 cm., and indicates for the entire animal a length of about a mètre. An impression of the skin is preserved; enlarged 45 times it shows a



Dolichosoma longissimum, upper surface of skull restored, enlarged six times.

fine granular structure, so that if any scales existed they are not preserved.

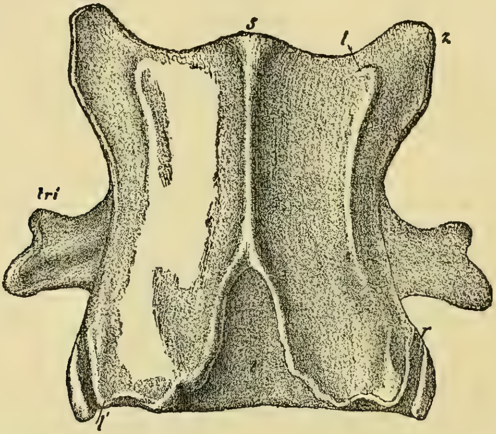
The eyes are placed rather behind the middle line of the skull, and are separated by an interspace of two-thirds their diameter. The parietal foramen lies far behind the orbits. The anterior nares cannot be distinguished. The nasal bones (*N.*) are anchylosed together, and forked behind. The premaxillaries (*im*) resemble those of *Siren lacertina.* The maxillary (*ms*) is a strong bone extending to the anterior extremity of the snout, and to the middle of the orbit; it carries about 15 smooth teeth, which are curved backward: there may have been two rows. The frontal and parietal bones are blended into one mass. The frontal terminates in front in three processes. The epiotic terminates at its outer angle in a knob-like swelling. The teeth of the lower jaw, 20 in number, were smaller than those in the upper jaw. There are indications of a branchial skeleton extending to the sixteenth vertebra. One hundred and fifty vertebræ are preserved, but there may well have been fifty more. In the neck the ribs are simple, in the body they are complicated, and in the tail they are absent. The dorsal vertebræ have a depressed elongated quadrate form, with a ridge in the position of the neural spine; the neural arch is constricted in the middle, and terminates at its four corners in zygapophyses. The transverse processes are compressed, directed downward and outward, and given off from the lower margin of the front of the centrum. The centrum has a circular cup at each end, and the cones unite, so that the notochord was persistent. The form of this vertebra may be compared with that of *Epicrium glutinosum.* Each vertebra has a slightly different shape. The tail vertebræ are smaller and shorter, and have weak zygapophyses, and are perforated in the middle of the side as though for the passage of an intervertebral nerve. The ribs of the neck at the sixteenth vertebra are twice as long as the centrum. The dorsal ribs show towards the proximal end two peculiar processes. The proximal end is bent at nearly a right angle to the body of the rib; the processes occur at the flexure, one is dorsal, and the other has a ventral direction. These processes present some analogy to the uncinate processes on the ribs of birds.

The author next describes *Dolichosoma* (*Ophiderpeton*?) *angustatum* (Fr.). The parieto-frontal region of the skull is very similar to that of *Dolichosoma longissimum.* There is some uncertainty felt as to its exact generic relations. The next genus in this family is *Ophiderpeton*, of which five species are described.

Ophiderpeton granulosum (Fr.) is covered on the back with horny shagreen-like scales, while the ventral surface is covered with small scutes pointed at both ends, half as long as the vertebræ, and arranged in a V pattern. The ventral scutes are parallel to each other, half as long as the vertebræ. The body in form resembles *Dolichosoma.* It is impossible to estimate its length, for the sixty vertebræ preserved show no variation in size. The skull is badly preserved.

The neural arch of the vertebra is deeply notched posteriorly (*i*). From the posterior zygapophyses deep grooves (*r*) run forward and outward. The transverse processes (*tri*) are near the middle of the centrum. The ribs are formed on the general plan of those of *Dolichosoma,* but the transverse processes are longer and nearer to the posterior end.

Ophiderpeton pectinatum (Fr.) is only known from a few vertebræ, some parallel pointed abdominal scutes and remarkable pectinated plates, supposed by the author to have been clasping sexual organs placed in the region of the cloaca; but their true nature may be doubtful.



Upper view of vertebra of *Ophiderpeton granulosum* (Fritsch), enlarged 12 times.

Ophiderpeton vicinum (Fr.). The ventral surface of the body was covered with oat-shaped scutes, while the dorsal armour had a shagreen-like character. The armour is similar to that of *Ophiderpeton Brownrigge* (Huxley).

Ophiderpeton Corvinii (Fr.) is founded on two specimens of a large pectinated plate.

Ophiderpeton Zieglerinum (Fr.) is founded on ventral armour in which the scutes are from 16 to 20 times as long as broad.

Palæosiren Beinertii (Geinitz) is briefly noticed and regarded as nearly related to *Ophiderpeton*; its vertebræ are 10 cm. long and 8 cm. wide, indicating an animal that may have been fifteen mètres in length. The armour is well developed.

This part of the work concludes with a notice of *Adenoderma gracile* (Fr.), of which the skin is well preserved, showing, as the author believes, glands arranged in four rows. The head is crushed, as long as wide, and one-fifth as long as the body. There are 22 short biconcave vertebræ between the head and pelvic region. Five caudal vertebræ are preserved. Short ribs are developed on the first 13 vertebræ.

Towards the end of the memoir Dr. Fritsch enunciates the conclusion that the *Stegocephali* may prove to be the ancestors both of

Amphibians and Reptiles, a sound induction which must long have been making its way with philosophical naturalists.

It is impossible to conclude this brief notice without congratulating the author on the admirable way in which the memoir is progressing. It is indeed a model of monographic work, wrought out of materials that would have discouraged if they did not baffle a writer less patient, able and painstaking than Dr. Fritsch, and may well call out the sympathy and admiration of his fellow-labourers among fossil vertebrates. H. G. Seeley.

II.—Mémoire sur les phénomènes d'altération des dépôts superficiels par l'infiltration des eaux météoriques étudiés dans leurs rapports avec la géologie stratigraphique. Par Ernest Van den Broeck. 4to. pp. 180. One Coloured folding Plate, and 34 figures in the text. (Brussels, 1881.)

THIS handsome Memoir forms part of vol. xliv. of the quarto series published by the Royal Academy of Sciences of Belgium under the title of "*Mémoires couronnés et Mémoires des savants étrangers.*" In it Mr. Vanden Broeck, who is well known as one of the most zealous and active of the younger naturalists and geologists of his country, has brought together a great number of facts relating to the alteration of superficial deposits by the action of rain-water. This subject was first taken up by the author in 1874, and since that time he has taken every opportunity, by means of papers describing special cases exhibited in various portions of the Tertiary basin of the Netherlands, of calling the attention of geologists to the frequent misreading of sections, due to the want of care in distinguishing the altered, but undisturbed, parts of beds or groups of beds from unconformable deposits. One of the first cases of the kind, clearly explained by him, related to the Laekenian and Bruxellian of the Brussels Eocene. Here unfossiliferous sands, resting upon what had been generally regarded as strongly eroded surfaces of fossiliferous more or less calcareous rock, were shown to be really undisturbed portions of the latter, from which the carbonate of lime had been removed, and in which other changes, such as the oxidation of glauconite for instance, had taken place, by the action of rain-water.[1] This is a fair sample of the kind of useful application that can be made for stratigraphical purposes of a proper knowledge of the results of the long-continued percolation of carbonated waters through sand and other deposits. Of course these effects have long been known to chemists and geologists, but their application towards the unravelling of the often obscure details of Tertiary geology is very largely, if not altogether, due to Mr. Vanden Broeck.

In the present Memoir, after some general considerations respecting the *rôle* of water, and especially rain-water, as an agent in the metamorphosis of rocks, the author describes its special action on felspathic, metalliferous, clayey and shaley, siliceous, and calcareous

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[1] See *Annales de la Société géologique du Nord*, t. iii. p. 174.

rocks. The original matter of the paper is chiefly to be found under the last head, and in an appendix on infiltrations in Quaternary deposits.

All the sections described seem to bear out the author's views very completely, but since many competent observers have failed to admit them in certain cases, such as that of the Red Drift of Paris, which Professor Hébert declines to regard as altered Grey Drift, it must be concluded that the evidence is not always so clear and satisfactory. But although all Mr. Vanden Broeck's examples may not be accepted as proven by those specially conversant with the detailed structure of the many districts whence they have been collected, there is no reason to doubt the general truth and the important nature of his thesis. Indeed, illustrations are not wanting in England, as in the case of the shelly Red Crag of Suffolk, where Mr. Whitaker has shown that the supposed line of erosion between it and a certain unfossiliferous sand is really a line of dissolution of shells, the sand being simply Red Crag deprived of its fossils through the percolation of water.[1]

On the whole, Mr. Vanden Broeck's Memoir must be welcomed as being, up to the present, the most complete epitome of a class of facts of considerable geological importance, which had been singularly neglected and ignored, until our author took them in hand in his own vigorous and enthusiastic manner.

It may be added that Mr. Vanden Broeck would be glad to receive information as to any new facts or objections relating to the subject of his Memoir. G. A. L.

III.—The Geology of Central and Western Minnesota. A Preliminary Report by Warren Upham, Assist. on the Geol. and Nat. Hist. Surv. of the State, under the direction of Prof. N. H. Winchell, of the State University. From the General Report of Progress for 1879. 8vo. pp. 58.

UNDER a rather unpromising exterior, this memoir includes several matters of special interest. It will also attract attention from the fact that it is the first report of the first student of Glacial Geology ever officially employed in his special capacity for a considerable period, and in a region over most of which glacial deposits prevail exclusively.

In consequence of the paucity of natural exposures (which is a circumstance not to be deplored, since natural sections are so generally misleading), recourse has generally been had to artificial excavations, mainly wells, in determining the character of the glacial deposits. The records of no less than 582 wells have been examined and digested in the preparation of the report. A compact lower till, usually blue, and a less compact upper till, usually yellow or brownish, both containing considerable intercalated sandy and pebbly layers, are recognized as of general extent; and local deposits of modified drift, often presenting a kame-like aspect, are also described. Inter-glacial beds, containing soil, wood, plants, and

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[1] See Quart. Journ. Geol. Soc. Lond. vol. xxxiii. p. 122.

fresh-water or terrestrial shells, are recorded in a few instances, apparently always within the lower till, but generally near its upper surface. The superposition of glacial drift upon decomposed gneiss and granite is noted.

Much attention has been given to the gigantic terminal moraine stretching in a sinuous line across Minnesota, and Dakota, and thence north-westward far upon the Saskatchewan plains in the adjacent British territory. The same moraine has already been traced across Wisconsin by Prof. T. C. Chamberlain, the director of the Geological Survey of that State, and is believed to exist also in Illinois, Indiana, Ohio, Pennsylvania, New York, and New Jersey. Beyond it has been explored by Upham along the north shore of Long Island, through Rhode Island, and along Cape Cod. The moraine thus appears to stretch, though with several interruptions, across more than half of the continent. It lies near the southern limit of ice-action in the east; but in the west it is fully three hundred miles north of that line.

The silty deposits of the Red River Valley are described in some detail; and the exploration of their origin is a valuable contribution to the glacial theory. It is suggested that as the ice-sheet retreated over surfaces sloping to the northward, the waters derived from its dissolution accumulated in all depressions to the level of the south-lying divide. Such an accumulation is supposed to have taken place in the vast basin occupied by Red River and Lake Winnipeg; and for it the very appropriate name of *Lake Agassiz* is proposed. The silts of the region are regarded as the finer glacial debris suspended in, and finally precipitated by, the waters of this lake. The conception embodied in this hypothesis appears to have been first grouped, though in a general way, by N. H. Winchell. It seems to afford the first satisfactory key to a rational explanation of the stratified deposits so generally found on northwardly sloping glaciated regions. W. J. M.

IV.—Die Wealden-Bildungen der Umgegend von Hannover eine geognostisch-paläontologisch-statistische Darstellung von C. Struckmann. Mit fünf Tafeln Abbildungen. Hahn'sche Buchhandlung, 1880.

The author of this interesting work is already favourably known to our readers by "Der Obere Jura," reviewed in our volume for 1879. The Monograph now before us is a detailed description of the Wealden formation from the beds resting upon the Portland Limestone to the Hilsthon of the Chalk, near Hanover. The Wealden is divided into three stages, each forming a well-marked horizon of life.

I. The deepest is the "Munder or bunte Wealden-Mergel," representing the Purbeck beds of English geologists, and consisting of thick beds of limestone interstratified with beds of marl, in which are numerous specimens of *Exogyra virgula,* fossils are rare, the most abundant is *Corbula mosensis,* Buv. They attain a thickness of 120 mètres, and belong to the Upper Kimmeridge. Over these follow dark-coloured beds, twelve mètres in thickness, of almost black marly limestone and shales. Rich in fossils, as *Exogyra virgula*, *Pecten concentricus*, *Gervillia obtusa*, *G. tetragona*, *Cardium eduliforme*, *Isocardia striata*, *Cyprina Brongniarti*, *Thracia incerta*, *Corbula mosensis*, *C. inflexa*, *C. alata*, *Turritella minuta*, and rarely also *Serpula coacervata*. These beds belong to the Lower Portland, and on them rest beds of the Upper Portland with few fossils, on which follows the Serpulit or Purbeck Limestone, consisting of very different strata, such as hard blue siliceous limestone, fine Oolitic limestone, clayey and sandy marls, with clay and sandstone, in which thirty species of organic remains are known. *Serpula coacervata* is found alone, and whole banks are filled with this Annelid—hence the name *Serpulit*.

II. The Middle Wealden, or the group of Hastings sandstone, rests upon the Serpulit. It consists of thick beds of fine-grained, yellowish-white, or greyish durable sandstone, which for its excellent quality has been employed in building Cologne Cathedral; and other hard beds called Blaustein are used for road material. The thickness of the sandstone amounts to 500 feet, and some of its beds contain a rich fossil flora of thirty-three species. The following are the most abundant: *Sphenopteris Mantelli*, *Pecopteris Geinitzii*, *Mantonidium Goepperti*, *Microdictyum Dunkeri*, *Hausmannia dichotoma*, *Anomozamites Schaumburgense*, *Sphenopteris Sternbergiana*, *Sph. Kurriana*, *Spirangia Jugleri*. The Mollusca consist of moulds and compressed shells. The osseous remains of Fish and Saurians are rare, but single scales of *Sphaerodus semiglobus* and *Lepidotus Mantelli* are abundant. Our author has found at Bad Rehburg the foot-prints of Reptilian animals, *Ornithoidichnites*, similar to those described and figured by Mr. Beckles, from the Hastings sandstone of Bexhill, near Hastings.

III. The Upper Wealden or Weald Clay consists of dark grey or blackish, thin-bedded, friable sandy shales and marl; a quartzite rock with thin beddings of limestone, and an abundance of *Cyrena*, *Cyclas*, *Corbula* and *Melania* species, *Melania strombiformis*, *Melania rugosa*, *Paludina fluviorum*, and other beds with Cyrena species, Cypris, and Fishes' scales. The Upper Wealden varies in thickness from 15 to 40, and 65 to 77 mètres. The fauna of this Upper member of the Wealden is limited to a few species, as *Mytilus membranaceus*, *Modiola lithodomus*, *Unio Menkei*, many species of *Cyrena*, *Corbula* and *Cyclas*, with *Melania harpaeformis*, *M. strombiformis*, *M. rugosa*, *Paludina*, *Litorinella*, *Planorbis*, *Cypris Valdensis* and two others, and the remains of Fishes, as *Pycnodus*, *Sphaerodus*, *Hybodus;* of fossil plants only indistinct traces have been found.

Under the lowest member of the Wealden, the Munder-Mergel, lies the Einbeckhauser limestone, which belongs to the Upper Portlandian, representing a portion of the Upper Jura, and forming, it may be, passage-beds from the Portland to the Wealden. The Serpulit maintains by its organic remains the predominant character of the Wealden, so that it cannot be separated from both the upper divisions. The entire Flora and Fauna of the Wealden formation has a Jurassic character, and the relations of the Lymneen and Brackish-water deposits of the Wealden with the Marine beds of the Portland, afford evidence of the alternation of conditions which prevailed during the close of the Jurassic epoch.

The plates which illustrate the Monograph are beautifully executed. The number of species amounts to 146, of which there are—

Plants	33	species	belonging to	24	genera.
Conchifera	62	,,	,,	9	
Gasteropoda	21	,,	,,	6	
Annulata	1				
Insecta	1				
Crustacea	8	,,	,,	2	
Fish	18	,,	,,	8	
Reptiles	2	,,	,,	2	
	146			51	

The construction of the Palæontological table and catalogue of species is to be highly commended, seeing that it brings before the eye at a glance the most important points connected with the history of the Fauna and Flora of the Wealden and associated formations. One column contains the name and synonym of each species, another the literature of the same, a third their distribution in the Kimmeridge and Portlandian, a fourth in the Purbeck and Wealden, and a fifth contains localities and general remarks thereon. All students who aim at precise and concise methods in order to represent the ancient life history of any formation may well take a lesson from these tables. This work will be welcomed by all geologists who take an interest in the marvellous chapter of the Earth's history to which it relates, and especially so to English naturalists acquainted with the correlated beds of the Wealden in our Southern Coast sections, which they can now compare with those in the neighbourhood of Hanover.
J. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

April 27, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Precise Mode of Accumulation and Derivation of the Moel Tryfan Shelly Deposits; on the Discovery of similar High-Level Deposits along the Eastern Slopes of the Welsh Mountains; and on the Existence of Drift-zones showing probable Variations in the Rate of Submergence." By D. Mackintosh, Esq., F.G.S.

The author commenced by giving a sketch of the progress of discovery connected with the Moel Tryfan deposits. He then described certain phenomena connected with these deposits, to which little or no attention has been devoted by other observers. After identifying the local stones, and indirectly local erratics, he traced the derivation of the far-travelled erratics which came from the N. and N.W. He drew particular attention to an extensive exposure of slaty laminæ, the edges of which have been bent by a force assailing the hill from the N.W.; and as these edges have been shattered so as to form parcels of slate-chips covered by, or rolled up in laminated sand, along with parcels of clay, he endeavoured to prove that a stranding of the floating-ice which must have brought part of the erratics (including numerous chalk-flints), will alone account for the phenomena. After describing patches of gravel and sand in other parts of Caernarvonshire, referring to the Three-Rock Mountain deposits in Ireland (which must have come from the N.W.), and briefly noticing the drifts on Halkin Mountain, Flintshire, he entered upon the main subject of his paper, namely, the discovery of an extensive series of marine drifts, including (besides deposits on flat ground) about twelve hillocks or knolls, consisting of rounded gravel and sand, and in at least two instances, containing gravel-pits with numerous shell-fragments. They extend along the east side of the northern part of the mountain-range which runs between Minera and Llangollen Vale, and are situated at levels between 1100 and 1300 feet above the sea. The gravel is largely made up of rounded Eskdale-granite pebbles, and during his last or fourth visit to the district, he found a large granite boulder on the axial summit of the ridge, about 1450 feet above the sea, showing a submergence of the mountain to at least that extent. He went on to assign reasons for believing that the sea lingered longer at the level of the sand and gravel knolls than lower down and higher up, so as to allow time for the extra rounding of the pebbles, accumulation of erratics, and multiplication of Mollusca; for he could discover no reason for supposing that the mollusks which left the shells did not live on or near the spot in the littoral or sublittoral zone. He then described a small exposure of high-level rounded gravel and sand near Llangollen, and dwelt on the remarkable fact that the marine deposits on Moel Tryfan, Three-Rock Mountain (Ireland), Minera Mountain, and in Macclesfield Forest, occur at about the same altitude above the sea-level. After proposing a provisional classification of the drift-deposits of North Wales and the Pennine hills into zones, showing probable variations in the rate of submergence, he concluded by discussing the question, Whether the submergence was caused by the subsidence of the land or the rising of the sea, without venturing to express any decided opinion on the subject, but inclining to the former idea.

2. "On the Correlation of the Upper Jurassic Rocks of England with those of the Continent." By the Rev. J. F. Blake, M.A., F.G.S. Part I. The Paris Basin.

This was an attempt to settle the many questions of correlation arising out of the detailed descriptions given of the various localities in the Paris basin where Upper Jurassic rocks are developed, by a consecutive survey of them all; undertaken by the aid of a grant from the "Government Fund for Scientific Research." In previous papers the names used for the great subdivisions and their boundaries were adopted without material modification; in the present such modifications were proposed as may bring the English and continental arrangements into harmony.

Five distinct areas were considered in this paper. *a.* The southern range; *b.* The Charentes; *c.* Normandy; *d.* The Pays de Bray; *e.* The Boulonnais.

a. The Southern Range.—This is continuous from the Ardennes through the Meuse, Yonne, etc., to the Cher. In the Ardennes the "Ferruginous Oolite" corresponds to our Osmington Oolite, and to the Lower Limestones and Passage-beds of Yorkshire, the underlying "Middle Oxfordian" being equivalent to our Lower Calcareous Grit. Above comes immediately the Coral Rag with *Cidaris florigemma*; and the stratigraphical and palæontological break is constantly between the Coral Rag and Ferruginous Oolite when that occurs. The Corallian is a well-marked formation, though its character is variability. It is divisible generally into two groups—Coral Rag and Supracoralline beds, the latter usually being the "*Diceras*-beds"; but in the Yonne there is a great development of *Diceras*-beds below, associated with *Cidaris florigemma* and massive corals, which is gradually introduced in going west. This part of the series in the Haute Marne has been described as very different; but the author did not at all agree with M. Tombeck's stratigraphical determination, and considers the "Oolite de la Nothe" no more than the continuation of the Supracoralline *Diceras*-beds, which he considers to uniformly *overlie* and never to underlie the *Am. marantianus* marls, which latter are Oxfordian. In fact nothing abnormal occurs in this Department. The whole series has a tendency to degenerate into barren lithographic limestones, in which distinctions are lost. The Astartian and Virgulian beds were traced through this range, the latter seldom showing any well-marked Pterocerian division, and the former being mostly connected with the overlying series. Above these are limestones hitherto called "Portlandian," in which two zones are constant; but above all are vacuolar Oolites, which alone may be truly correlated with the Portland rocks of England. The whole of the beds in this range are eminently calcareous, a true clay being scarcely anywhere seen.

b. The Charentes.—In these two Departments the lower portion is very calcareous, and the distinction of one part from another very slight; but the highest portion, both near Cognac and on the Ile d'Oleron, yields beds which may be paralleled with our true English Portland rocks.

c. Normandy.—The complete sequence has here been made out, from the true Oxford Clay of Dives to the Virgulian of Havre, and the similarity of the whole to the sequence in Dorsetshire is very remarkable. "The Trouville Oolite" is the exact representative of the "Osmington Oolites" with the Nothe Grits below; but the place of the Sandsfoot clay is taken by the true Coral Rag, whose right position in the Weymouth section is hereby determined. The Supracoralline beds are the sands of Glos, and the Astartian beds are the *Trigonia*-beds of Havre, which are the exact representatives of the "Kimmeridge passage-beds."

d. The Pays de Bray.—Nothing below the Virgulian is here seen, and the commencement of the so-called "Portland beds" was considered by the author to be at a lower level than it is placed by M. Lapparent, on account of the similarity to beds at Boulogne. The true Portland rocks occur as ferruginous sandstones with *Trigonia gibbosa*.

e. Boulonnais.—The Houllefort limestone was correlated with the Osmington Oolite. The Coral Rag of Brucdale was considered equivalent to that of the Mont des Boucards, the so-called limestones of the latter place being Supracoralline. The Nerinæan Oolite and the Gres de Wirvigne represent the Astartian. The higher parts of the series have been already correlated.

From this study it was proposed—that the "Lower Calcareous Grit," and almost all the Coralline Oolite should be placed in the Oxfordian series as the upper division, under the name "Oxford Grit," and "Oxford Oolite"; that the Corallian consists of two parts, the Coral Rag and the Supracoralline beds; that the Kimmeridgian should include the Astartian and Virgulian, the Pterocerian being a subzone; that the "Upper Kimmeridge" and the Hartwell clay, with the "Portland sand," should make a new subdivision to be called Bolonian, the northern and southern types being both represented at Boulogne, which may be divided into Upper and Lower; and that the true Portland limestone and the Purbeck be united into one group, as Lower and Upper Portlandian; the fact of the latter being freshwater being paralleled by parts of the true Portland having that character.

3. "On Fossil Chilostomatous Bryozoa from the Yarra-Yarra, Victoria, Australia." By Arthur William Waters, Esq., F.G.S.

The author gave a descriptive list of seventy-two pieces of Bryozoa belonging to the suborder Chilostomata, from a lump of clay obtained by Mr. Allen from the neighbourhood of the Yarra-Yarra River. The specimens are fragmentary, but in excellent preservation. There are eight species of *Catenicella*, a genus unknown in the fossil state until quite recently, when Mr. Bracebridge Wilson described twelve fossil species, none of which are known living; two of the Yarra-Yarra species still live in the Australian seas, and one of these also occurs in the Geological Society's collection from Mount Gambier. Among the most interesting of all the specimens described by the author is a *Catenicella*, consisting of long internodes, with a double row of cells in each internode. The short-beaded *Catenicellæ* now living have probably been developed from forms with long internodes. *Microporella* is also well represented by some interesting forms, which make it necessary to widen the definition of the genus. A very interesting *Cellaria* with subglobular internodes explains the Cretaceous fossil called *Eschara aspasia* by d'Orbigny.

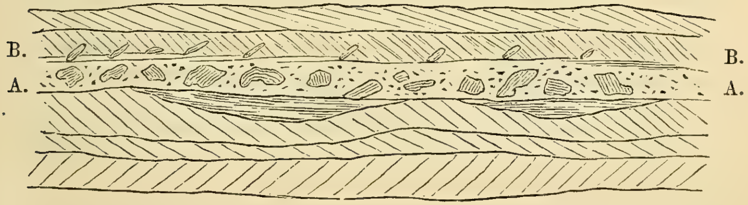
Of the Chilostomata found in this deposit thirty-nine are considered new, although this number may have to be reduced; nineteen are now found living; seven correspond with those from the fossiliferous beds of Orakei Bay, New Zealand, described by Stoliczka; about twenty-three are found in the Mount Gambier formation. Of about thirty Cyclostomatous Bryozoa which occur in this deposit, at least seven are common to it and Orakei Bay. Besides the Bryozoa, the author has obtained many other organisms from this clay, and especially a large number of Foraminifera now in the hands of Prof. Karrer of Vienna. He estimates the total number of determinable species belonging to various classes at over 200.

In treating of his special subjects the author adopts the principles of classification laid down by Hincks, Smitt, and other recent writers on living Bryozoa, which he regards as preferable in themselves, and also as facilitating the comparison of fossil with recent forms.

CORRESPONDENCE.

GLACIAL BOULDERS IN SECONDARY DEPOSITS, SIDNEY, NEW SOUTH WALES.

Mr. C. S. Wilkinson, F.G.S., Government Geologist, Department of Mines, Sydney, N.S. Wales, referring to the occurrence of Glacial boulders in the "Hawkesbury Series,"[1] writes to Mr. R. Etheridge, jun., under date 10th February, 1881:—"Here we have huge and small angular masses of soft shales embedded in pebble conglomerates and false-bedded sandstones. With these sandstones (Hawkesbury) are interstratified argillaceous shales, and the boulders are of the same material and contain the same fossils. It seems that during the deposition of the Hawkesbury Series, the rapid and changing currents which deposited the false-bedded sandstones, were at intervals succeeded by quiet waters, from which the mud forming the shales settled down, probably during winter-time, when ground-ice formed. Spring-time following, the ice broke up, and drifting about broke up some of the newly-formed shales, and mingled the shale fragments with pebbles and sand brought by currents from the shores. The shale boulders are always found just *above*, or not far from the undisturbed shale-beds, thus:—



In the sandstones just above the bed with angular blocks (*A*), are (*B*) small rolled flattish pieces of the same shale, the longer diameter inclined in one position, showing the direction of the transporting currents at the time; some of the angular masses are curved, showing that they must have been in a soft condition, when torn up from the underlying shales. The principal fossils found in these are fragments of Plants—*Phyllotheca, Thinnfeldia, Odontopteroides*; Fishes—*Palæoniscus, Cheirolepis granulatus, Myriolepis Clarkii,* and another, which appears to be new."

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[1] Lower Mesozoic.

THE BAGSHOT BEDS OF THE BAGSHOT DISTRICT.

Sir,—Being greatly interested in the geology of the London Basin, and having just read Professor Jones's paper on the Bagshot District (Proc. Geol. Assoc. vol. vi. No. 9), I at once turned to Mr. Herries' article with the above title, on receiving the current Number of the Geological Magazine, to be however "brought up sharp" by the first paragraph (p. 171).

The statement that "the *only* authority for the beds included in this area is Professor Prestwich, who . . . . has supplied *all* the information about the district that is at present known," quite astonishes me, at least as far as regards the words which I have italicized. No one is more ready to bear witness to the great value of Professor Prestwich's many papers on the London Basin than I am, for no one, probably, has used them more; but that great authority on Tertiary geology would never claim such an exclusive right to the Bagshot District, the structure of which he made out and first described in detail.

There happens to be an institution known as the "Geological Survey," whose work consists in recording the details of the geology of these islands. Some of its officers (chiefly a former colleague, Mr. Polwhele, a Cambridge man) years ago surveyed the Bagshot District, and the result of their work has been published on the Geological Survey maps. Moreover, in the course of my own work on that Survey, I have a distinct recollection of running one of the so-called "Horizontal Sections" across that district, and of having corrected the proofs of a Memoir (vol. iv. 1872) that gives a detailed description of the Bagshot Beds, and in which, I believe, the pebble-beds were for the first time described at any length.

This note is not written with any wish to disparage Mr. Herries' work; on the contrary, I welcome an addition to the ranks of our Tertiary geologists, and congratulate him on his enlargement of the local Bagshot fauna. My object is to caution young geologists against rashly assuming that they know everything that has been done in any district. That such an error should have come from the Woodwardian Museum is astonishing, as Professor Hughes, himself an old Survey man, could at once have enlightened his pupil.

To conclude, I assure Mr. Herries that, should a second edition of the Geological Survey Memoir on the London Basin be called for, I shall make use of his paper and acknowledge his discoveries, to which I hope he may make many additions.

Geological Survey Office, William Whitaker.
28, Jermyn Street, London, S.W., 11 *April*, 1881.

PENTREMITES IN THE MIDDLE DEVONIAN OF DEVON.

Sir,—*Pentremites* not being as yet in the British Middle Devonian lists, may I mention their probable occurrence in the neighbourhood of Torquay? I have placed two specimens, apparently of different species, in the hands of Mr. R. Etheridge, jun., who (with Mr. P. H. Carpenter) has kindly promised to examine and describe them. He pronounces them to be *Blastoidea*, though from their state of preservation the genus requires further investigation. One bears a superficial resemblance to *Pentremites planus* (Sandb.). A third specimen, also fragmentary, is in the collection of Mr. J. E. Lee.

Charante, Torquay. G. F. Whidborne.

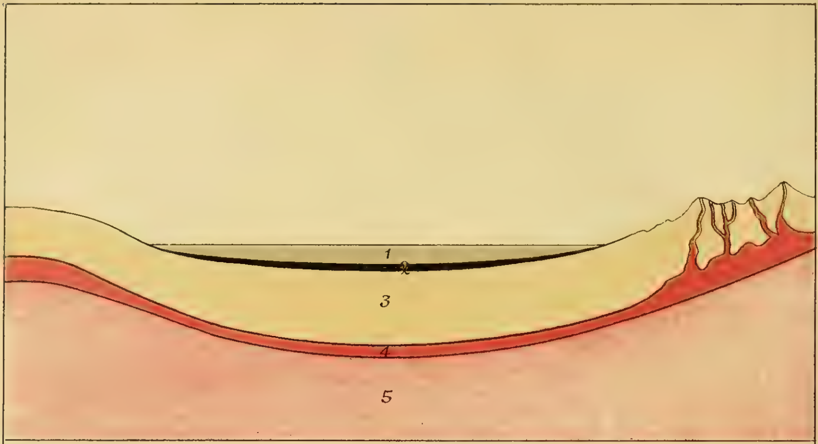
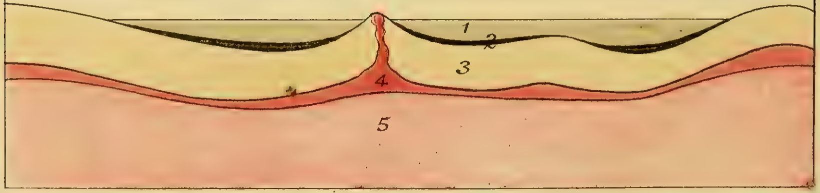


Fig. 1.

Fig. 2.



G. M. Woodward del. Fig. 3. West Newman & Co. lith.

Fig. 1. *Ideal Section across Ocean Basin.*
1. Sea. 2. Accumulated sediment. 3. Solid rock, converted at 4. to fluid by pressure. 5. Solid central mass.
Fig. 2. *The Pacific basin, showing encircling volcanos, from Scrope.*
Fig. 3. *Ideal Section as in Fig. 1. but showing submarine lines of least resistance.*

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No. VII.—JULY, 1881.

ORIGINAL ARTICLES.

I.—NOTE IN EXPLANATION OF PLATE VII., TO ILLUSTRATE THE THEORY OF SUBSIDENCE AND ELEVATION OF LAND, AND THE PERMANENCE OF OCEANS.[1]

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

FIG. 1 is intended to represent a section across an ocean basin. It is supposed that the combined weight of water (1) and sediment (2), acting upon an elastic layer of rock (3), compresses the fluid layer which underlies it (4), and forces it to escape laterally, and either to accumulate and partially solidify, thus raising the crust above; or, where the tension is extreme, and the resistance inadequate, to form fissures or vents. The continuously sustained pressure towards the centre of the basin constantly converts fresh solid into fluid, which escapes again and again, perhaps at intervals of centuries, causing fresh upheavals or eruptions, perpetually deepening the ocean basin.

The relative mass of sediment to crystalline rock may be enormously greater, since its accumulation must have been increasing from the remotest ages.

FIG. 2 represents the basin of the Pacific with its encircling chain of volcanos, and is after Scrope.

FIG. 3 is an ideal section similar to that of Fig. 1; but showing in addition sub-marine lines of insufficient resistance.

In the article, reference to one of the most striking examples of subsidence being directly due to weight of sediment was omitted.

The constant influx of brackish water seen in our coal-fields, and the nature of coal, show beyond doubt that it was deposited at or about the sea-level, yet in the South Wales district the Coal-measures are 10,000 to 12,000 feet thick, with 75 distinct seams.

II.—ON THE GENERA *MERISTA*, SUESS, 1851, AND *DAYIA*, DAV. 1881.

By THOMAS DAVIDSON, F.R.S., etc., etc.

IN his memoir "Brachiop. der Kössener Schichten," p. 17, Prof. E. Suess proposed his genus *Merista*, giving as its type the *M. Herculea*, Barrande, and at page 85 of the German edition of the general introduction to my work on British Fossil Brachiopoda Prof. E. Suess redescribes his genus, and in pl. iii. figures its spirals and shoe-lifter process; but neither the connexions of the spirals, nor their attachments to the hinge-plate, had then been discovered. Prof. Suess also includes in his genus *Merista* the so-called *Atrypa tumida*, Dalman (now the type of our genus *Whitfieldia*), whose

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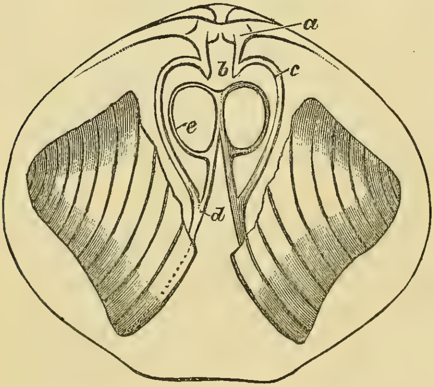
[1] This Plate should have accompanied Mr. Gardner's article which appeared in the June Number, see pp. 241–245.—EDIT. GEOL. MAG.

internal and differential characters were then likewise unknown. In our British Devonian rocks the genus *Merista* is represented by the *Merista plebeia*, or = *scalprum*; but although Mr. Glass has been able in several specimens to develope its spirals, he entirely failed to expose its loop, on account of the difficult nature of the limestone or opaque spar which fills most of the specimens.

Considering it to be very desirable that the interior character of this important genus should if possible be discovered, I wrote to my old and valued friends M. Barrande, of Prague, and to Prof. E. Suess, of Vienna, and requested them to kindly send me some specimens of *Merista Herculea*, that the Rev. Norman Glass might endeavour to work out the loop and the attachments to the hinge-plate, which had not been hitherto discovered; and thanks to his great skill, experience and patience, we are now acquainted with the whole characters belonging to the genus under description.



Interior of the dorsal valve of *Merista Herculea*.
Developed by the Rev. Norman Glass.

The principal stems forming the spirals are attached to the hinge-plate *a*; from thence they proceed for a short distance into the interior of the shell with a very gentle inclination forward, and at *b* they are abruptly bent backwards at an acute angle towards the bottom of the lateral portions of the beak. From thence they form a broad rounded curve facing the bottom of the dorsal valve *c*, and after converging to about half their length, again divide towards the front, and thus form the first spiral coil. Again, at about half their length, at *d*, the principal lamellæ widen and give off another lamella. These lamellæ converge from both sides towards the middle of the interior of the shell between the spiral coils, and after the two extremities have come into contact, the lamella thus formed proceeds in a straight direction for a short distance to near the hinge-plate, and then bifurcates and curves round on each side, forming two slender rings *e*. The anterior border of these rings being attached a little below the place where the converging lamellæ of the loop become united. The outer edges of the rings slope gently towards the bottom of the dorsal valve, and are rather less in width than the primary branches to which they are attached. The spiral cones are composed of ten or twelve convolutions, the number, however, varying in different specimens and at different stages of growth. The extremities of the spirals are directed towards the middle of the lateral portions of the shell.

In the ventral valve, under the beak, are two roof-shaped plates fixed by their lateral margins to the medio-longitudinal region of the valve and with their narrow end fitting under the extremity of the beak. Prof. King compared these plates to a shoe-lifter process.

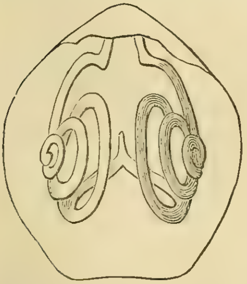
With very small differences the loop of *Meristella*, Hall (*M. arcuata*, Hall), is similar to that we have described in *Merista*, and were it not that *Meristella* has no shoe-lifter process, it would not be possible to distinguish the two genera.

Again, *Whitfieldia* (*Atrypa tumida* of Dalman) is distinguishable from both *Merista* and *Meristella* by the absence of those peculiar ring-shaped processes attached to the loop, and has instead only a short bifurcating process where in both the last-named genera the rings are formed. These three genera seem, indeed, closely allied, although each contains peculiarities by which it may be distinguished from the others.

Genus Dayia, Dav. 1881.

Type *Terebratula navicula*, J. de C. Sowerby, Sil. Syst., pl. v. fig. 17, 1837.

At page 191 of my Silurian Monograph, I say, "Surely this shell differs much, both by its external as well as its internal characters, from those peculiar to the genus *Rhynchonella:* so much so that it may hereafter be found desirable to propose for it, and similarly characterized shells, a separate generic or sub-generic designation." In 1867 I was acquainted with the interior surface of both valves, and described and figured in detail its very remarkable muscular and other impressions; but I had no idea that the shell was provided with spiral coils for the support of the labial appendages. During the month of March, 1881, the Rev. H. G. Day showed me some fine specimens of the so-termed *Rhynchonella? navicula*, and offered to send them to the Rev. Norman Glass, that he might see whether the shell was possessed of spiral appendages, and on the 22nd of the same month Mr. Glass wrote me: "I now send you two specimens worked out of *R.? navicula*, showing entirely new spirals and loop," and since all the interior characters are so distinct from what we find in other spiral-bearing genera, Mr. Glass suggested that I should propose a new genus for the shell under description. It is very probable even that we have in our British Silurian rocks other species referable to the same genus, but we are at present acquainted with *Dayia navicula* only, so that the generic characters may be taken from that as the type. Exteriorly, *Dayia navicula* is elongated, oval or boat-shaped, broadest posteriorly—ventral valve very deep, convex, and arched, and keeled along the middle, beak closely incurved, dorsal valve slightly convex posteriorly, anterior half of shell concave, surface smooth. In the interior surface of the dorsal valve a slightly raised ridge extends from under the hinge-plate to about half the length of the valve, and on either side are two scars formed by the adductor muscle. On the internal cast the place occupied by the



Interior of the dorsal valve of *Dayia navicula*. Developed by the Rev. Norman Glass.

mesial ridge forms a longitudinal groove, the muscular impressions being slightly in relief on either side. The sockets are widely separate. The primary stems of the spirals are attached to the hinge-plate of the dorsal valve, and after extending parallel to each other for a short distance, bend at right angles abruptly towards the lateral portions of the beak, and form two large curves facing the lateral portions of the valve. On approaching the front they form four or five convolutions, which become smaller until they reach their terminal coil, which faces the middle of the lateral portions of the shell. Near the front the primary lamellæ give off two processes, which converge and extend between the spiral coils in an upward and backward direction. After becoming united towards the middle of the shell, they are again prolonged in the shape of a single lamella, which proceeds upwards for a little distance with its extremity directed towards the hinge-plate. The spiral coils are therefore connected by a loop having a somewhat similar position to that described by Prof. J. Hall in *Zigospira*, but in this last named genus the spiral coils have their extremities facing each other in the centre of the shell, while in *Dayia* it is quite the reverse, the extremities of the spiral coils facing the lateral portions of the shell.

In the interior of the ventral valve a mesial groove extends from the extremity of the beak to about the middle of the shell, and on either side, running parallel with the hinge-line, are two broad, rounded projections, at the outer extremity of which are situated the articulating tooth; under these are two obliquely placed or chevron-like, elongated, oval-shaped muscular scars, considerably raised from the bottom of the valve, these projecting parts forming corresponding depressions in the internal cast.

We are therefore now, thanks to the incomparable skill of the Rev. Norman Glass, fully acquainted with the characters of the spiral arrangements of this remarkable genus, and which I name after the Rev. H. G. Day, in consideration of the important help he has always been ready to offer me in my investigations of the Silurian fossils with which he is so well acquainted. Placed by Sowerby in 1839 with *Terebratula*, by M'Coy in *Atrypa* in 1846, with *Hypothyris* by Phillips in 1849, with *Rhynchonella* by Salter in 1859, I hope it has now found a resting-place in *Dayia*, being entirely dissimilar from any of the genera above quoted. *Dayia navicula* seems confined to the Upper Silurian. It would be very desirable that the interior of the so-termed *Merista ? cymbula* should be examined, for it bears much external resemblance to *Dayia navicula*.

From the different articles we have inserted in this year's volume of the GEOLOGICAL MAGAZINE, it will be seen how very important it is to become acquainted with the loops and attachments of the spirals in the spiral-bearing genera of Brachiopoda. Indeed, it has been demonstrated from the admirable researches, so skilfully conducted by the Rev. Norman Glass, that it is impossible to feel certain as to the genus to which the larger number of the spiral-bearing species really belong until their interior details have been ascertained, and how fallacious it is to depend solely on external appearances.

We are, unfortunately, not yet acquainted with the internal character of the following Silurian British spiral-bearing species of Brachiopoda, and any one possessing duplicates available for that purpose could not serve science better than by placing them in the able hands of the Rev. Norman Glass:—*Meristella ? angustifrons*, M'Coy, sp.; *M. ? Circé*, Barrande?; *M. ? Maclareni*, Haswell; *M. ? crassa*, Sow.; *M. ? sub-undata*, M'Coy; *Atrypa ? hemisphærica*, Sow. sp.; *A. ? Scotica*, Dav.; *A. Headii*, Billings. The so-termed *Triplesia ? monilifera*, M'Coy; *Triplesia ? Grayiæ*, Dav.; *Merista ? camarium* or *cymbula*, Dav.; and the *Rhyn. ? Pentlandica*, also require internal investigation.

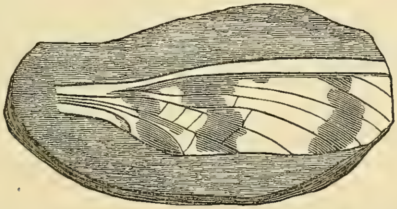
The Rev. Norman Glass has also recently been devoting much attention to the loop and spiral-bearing species of British Devonian Brachiopoda, with admirable results, which we hope to make known in the sequel.

III.—Two New British Carboniferous Insects, with Remarks on those already known.

By Samuel H. Scudder, Esq.

Assistant-Librarian, Harvard College Library, Cambridge, Mass., U.S.A.

BY the kind communication of my friend, the Rev. P. B. Brodie, M.A., F.G.S., I have been able to study two very striking wing-fragments from the Coal-measures of Great Britain, which are interesting, not only from the excessive rarity of such remains in this country, but also from their relationship to the two or three already known.



Wing of *Brodia priscotincta*, Scudder. Coal-measures, Dudley Coal-field, Staffordshire.

The first, which I call *Brodia*, in honour of the distinguished writer on the Insects of the Secondary rocks of England, is an ancient form of *Planipennia* or true *Neuroptera*, the structure of whose wings does not agree with that of any of the existing families of the group, but rather shows a combination of features which now distinguish separate families. It has the general aspect of a gigantic *Panorpa*, borrowed from its form, its markings, the presence of a few scattered cross-veins, and the course of the mediastinal nervure. When, however, its neuration is carefully observed, the scapular vein is seen to be fundamentally different, though its position and the origin of its main branch is similar; for, while in both cases the area it occupies is important, in the *Panorpina* the main branch divides dichotomously throughout, and its offshoots take a longitudinal direction; while in *Brodia* the main branch emits oblique shoots at regular intervals downward and outward, as it does in other *Planipennia*, but not in *Panorpina*; the veins below the scapular are also very different from what they are in *Panorpina*, and relatively to the rest of the wing much less important.

With the *Hemerobina*, the wide space between whose marginal and mediastinal veins is filled with numerous oblique and generally forked veinlets, and whose scapular vein has numerous sectors, this ancient type has less to do. In these, the mediastinal vein extends nearly to the tip of the wing, while in *Brodia* it terminates a little beyond the middle. The *Hemerobina*, however, differ from other *Planipennia* in the insignificant part usually played by the externomedian vein, which is frequently almost entirely simple or only forked once in the apical half of its course. This peculiarity is borrowed, though not in a striking degree, by *Brodia*, where this vein is forked once about the middle; but whose branches, widely distant like those of the scapular vein, cover a considerable area.

The more essential features of this ancient wing, however, foreshadow the characteristics of the *Sialina*. In form, while it is not very different, it has none of the arching of the costa almost universal among *Sialina*, and usually accompanied in modern types by a broad space between the marginal and mediastinal veins, not at all displayed by *Brodia*. In the brevity of the mediastinal vein *Brodia* resembles the *Raphidians*, but the neuration of the rest of the wing is completely different, while in the *Sialids* proper the mediastinal vein always continues nearly to the tip of the wing. The course and distribution of the branches of the scapular vein, however, are of greater importance, and in this respect *Brodia* agrees very well with the *Sialina*; again, however, the simplicity of the internomedian vein in *Brodia*, where it consists of only a single undivided ray, is very different from that now found in *Sialids*, where it is always divided and often plays a somewhat important part.

Brodia, then, is a *Planipennian* in a broad sense, refusing to affiliate closely with the restricted families of the present day. Nor does it appear to be intimately related to any Palæozoic insect yet described. It is also peculiar for possessing a very large number of fine cross-veins or wrinkles, besides the stout cross-veins which are scattered here and there over the wing; the latter are, however, confined to dark patches to be mentioned presently; while the former are uniformly distributed over the wing, subequidistant, and always run at right angles to the nervures they connect, even where, by keeping that course, they strike the often obliquely directed, stouter cross-veins.

In the preservation of its colours, *Brodia* is the most striking instance known among Palæozoic insects; the markings are sharply defined, and, to judge from Brongniart's illustrations, more deeply tinted than in *Protophasma Dumasi*, which he has described in this Magazine,[1] and elsewhere. The stone on which the wing of

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[1] Geol. Mag. 1879, p. 97, Pl. IV.

Brodia is preserved is of a dull grey colour, and the hyaline parts of the wing do not differ from it in tint. The margins of the wing, however, are nearly black, while the anterior part of the wing next the scapular vein is dull brown; below this are three broad transverse belts, one in the middle, and the others in the middle of either half of the wing, which, and especially the two outer, are of a distinct, though dull, umber brown; these belts are very irregular in outline, following in many cases the course of the transverse veinlets. All the margins of the wing are armed with fine black spinules, generally set in a double row.

From the excellent preservation of the markings the species may take the name of *Brodia priscotincta.* The wing as preserved is 44 mm. long and 12 mm. broad. The possible length of the complete wing was about 55 mm.

The second specimen is a fragment of the basal part of a wing, which, as it shows the roots of all the principal veins, can be placed with a strong degree of probability in the same general group as some other Palæozoic wings; and yet, as it differs strikingly from all of them in certain features, and from its immense size can be confounded with none, merits distinct mention and a name. The fragment itself must have been known for a long time, though I find nowhere any reference to it; besides the piece sent me by Mr. Brodie, I have casts of its reverse, given me about ten years ago by Mr. Woodward, the original of which is, I believe, in the British Museum.

This fragment is remarkable for representing the largest known insect-wing from the Palæozoic rocks, not excepting the *Acridites formosus* of Goldenberg from Saarbrück, or my *Megathentomum pustulatum* from Illinois. Certainly not more, probably much less, than the fifth of the wing is preserved; but the direction of the veins, their very great robustness, and the extraordinary distance apart of the upper three are clear indications that the spread of wing enjoyed by this insect was not less than ten, and may even have been more than fourteen inches; all the principal veins are a millimètre or more thick, and the cross-veins of the upper two interspaces are tolerably distant, stout, prominent, and generally simple. The marginal vein, forming the front border of the wing, is studded with short oblique spines. The other veins lie at very different levels on the stone, and, below the interspaces mentioned, seem rather closely crowded, and are much more curved, sweeping downward, while the upper veins show little tendency to turn from a longitudinal course. All the principal veins are present, and from their trend and relative level, and from the width and nature of the interspaces, there can be no question that the insect belongs to the same group with the *Corydalis Brongniarti* of Mantell, and the *Lithomantis carbonarius* of Woodward, and is, indeed, only to be separated generically from them.

For this gigantic insect the name of *Archæoptilus ingens* is proposed. The length of the fragment is 43 mm. and its width 32 mm.

This naturally leads to an inquiry into the proper zoological position of *Lithomantis carbonarius* and *Corydalis Brongniarti*, the "marked similarity" of which Mr. Woodward himself points out, figuring them side by side in describing the former.

Mr. Woodward is assuredly mistaken in referring *Lithomantis* to "the neighbourhood of the *Mantidæ*," notwithstanding that he supports himself by the adherence to his views of such able entomologists as Messrs. Westwood, Waterhouse and M'Lachlan, who can hardly have made a serious study of the neuration. It bears indeed a vague resemblance to that of the *Mantidæ*, excepting in the hind wings, where the fullness of the anal area, with its special development of folding rays in the insect of to-day, need not be looked for in its less specalized ancestor; but when the elements of the neuration are examined, the resemblance is seen to be purely superficial. Then it appears that *Lithomantis* agrees with other ancient types, and not at all with the *Mantidæ*. The front wing of the *Mantidæ* has a very peculiar and characteristic neuration. The marginal vein forms the front border of the wing, as I believe it never does in any saltatorial *Orthoptera*, and always does in the *Neuroptera*. The mediastinal vein is simple, and runs in close proximity to the scapular, terminating near the tip of the wing. So far there is nothing essentially different from the condition of things in *Lithomantis;* but in the next three veins all is different. To use the specific example (*Blepharis domina* of Africa) given by Mr. Woodward: the scapular vein is perfectly simple as far as the extreme tip, when it divides into three very short nervules supporting the apical margin. In *Lithomantis*, however, it emits a stout inferior branch near the middle of the wing, which runs parallel or nearly parallel to the main vein, and probably (if it is like its allies of the time) sends off several branches to the lower apical margin. As this is one of the principal veins of the wing, differences which occur here are significant, and there is hardly any group of insects which has so unimportant a scapular vein as the *Mantidæ*. The differences are even more striking in the next two veins, better preserved in the fossil. In *Blepharis* (and it is much the same in all *Mantidæ*) the externomedian vein is divided at base into two main stems, the upper of which runs in close proximity to the scapular, and in the outer half of the wing sends downward three or four conspicuous oblique veins, which appear at first glance precisely as if they were offshoots of the scapular, which they are not at all; they only perform the office of such offshoots in other wings; the lower branch takes an irregularly longitudinal course below the upper branch, and emits similar veinlets to the lower margin; and the entire area occupied by the two branches of this vein and their offshoots covers very much the larger part of the wing. The internomedian vein, on the contrary, is exceedingly simple, being forked only once (often, in other *Mantidæ*, not at all), and occupies much less space than even the anal area. Now in *Lithomantis* the case is very different; the externomedian vein does not divide at all until near the middle, and then only once or twice, its branches covering an area which is certainly much less than a quarter part of the wing, while the internomedian vein subdivides numerously, no less than eight final nervures reaching the margin and covering an area, certainly as great as, and apparently considerably greater than, that of the externomedian vein. These singular differences between the *Mantidæ* and *Lithomantis*, affecting the distribution of the three most important veins of the wing, leave no doubt whatever that the apparent resemblances between the two are only superficial, and that *Lithomantis* can with no propriety be referred to the *Mantidæ*.

What place then should be assigned to *Lithomantis?* I believe we should compare it with certain other Palæozoic wings, and notably with *Corydalis Brongniarti* of Mantell, to which indeed Woodward has himself compared it, giving at the same time an original figure of this interesting fossil.

This insect is especially interesting from its being the first discovered in Palæozoic rocks, and that at a time when, to use the words of Audouin, no fossil insect was known either from the Lower Oolite, the Lias, the Keuper, the Muschelkalk, or the New Red Sandstone; still less in any older rocks. How astonishing then it must have been to find this trace in the Coal! It was at first supposed to be a plant, and as such was sent by Mantell to Brongniart, with other remains from Shropshire. Brongniart placed it in Audouin's hands, and he drew attention to it on several occasions,—before the Entomological Society of France, the Academy of Sciences, and the Assembly of German Naturalists at Bonn, asserting its relationship to *Neuroptera*, where he placed it in the neighbourhood of *Hemerobius*, *Semblis*, *Mantispa*, and especially of *Corydalis*. Mantell accordingly figured it in 1839, in his Medals of Creation, under the name of *Corydalis*, adding in the second edition in 1844 the specific name *Brongniarti*. The figure given by Mantell is thoroughly bad, not one of the veins being correctly drawn, and giving an altogether false idea of the wing; that by Murchison, in the various editions of his "Siluria," is apparently made from the same drawing, and therefore almost equally bad; the anal veins alone are more correct.

No further notice appears to have been taken of this wing until, in 1874, Swinton, and again, in 1876, Woodward, gave us new illustrations of it, which leave little to be desired. Swinton thought he had discovered the relics of a stridulating organ at the base of the wing, and compared it to similar characteristics alleged to be present on the under surface of the front wing of the modern *Gryllacris*. He accordingly referred the wing to the *Orthoptera*, and even to the *Locustarian* genus *Gryllacris*. This view cannot possibly be maintained, and a more unfortunate comparison could hardly have been made. Swinton himself acknowledges that he could not succeed in finding a species of *Gryllacris* "with an effective file," and the resemblance of one he figures cannot be ascribed to a stridulating apparatus; for (1) the "file" he figures could not produce any sound when brought into contact with a similar structure on the opposite wing, since from their course the two would not be brought into the proper relations to each other, or at least into such relations as they always are brought in stridulating *Orthoptera;* (2) but it could not be brought at all into contact with the similar part of the opposite wing, the wing-insertions being far apart in *Gryllacris,* and the supposed file lying at the extreme base of a vein in the middle of the wing; (3) if this were a stridulating organ, it would not only lie in a different area from where it lies in all other *Locustarians,* but would agree with its place in no other *Orthoptera* whatever.[1]

The supposed file in *Gryllacris* being no stridulating apparatus, any comparisons between it and the fossil from this point of view are of course misplaced; but, aside from this, the position and course of the supposed file of the fossil is entirely different from that of the supposed file in *Gryllacris,* more indeed as it really is in *Locustarians.* But a careful examination of casts of both obverse and reverse, kindly given me by Mr. Woodward, and which show even more details than are given either by Swinton or Woodward (as, for instance, the spiny nature of the edge of the costal margin), brings nothing to light which lends any support to this supposition.

In his comparison of the general neuration of the fossil wing and the modern *Gryllacris,* Mr. Swinton's language is vague, but his conclusion, though evident, is wholly erroneous. It needs only the figures upon his plate to point out the essential differences in the neuration. In the first place, a distinction of prime importance appears in the marginal vein, which forms the border (and is heavily spined) in the fossil, is widely removed from it in *Gryllacris,* the margin being formed of a film supported by superior offshoots from the marginal vein, which of course do not exist in the fossil. In *Gryllacris,* the scapular vein is crowded with a narrow space, embracing on the margin only the extreme tip of the wing; while no such contraction appears in the fossil, where the area embraced by this vein must cover the entire apical margin. The externomedian vein of the fossil is closely crowded against the scapular at base, and parts from it beyond with a sweeping curve (as in most *Neuroptera*), appearing as if a branch of it; while in *Gryllacris* it lies midway between the adjacent veins, and has scarcely the slightest downward tendency, its branches being equally parallel instead of divergent. The internomedian vein in the fossil is widely separated on either hand from the adjoining veins; while in *Gryllacris* it is equally crowded with the others. Finally, all the branches of the latter, as well as those of the preceding vein, impinge upon the apical margin in *Gryllacris;* while in the fossil they strike the lower border of the wing.

These differences, many of which separate also most of the families of *Orthoptera* from those of *Neuroptera,* prove that the fossil

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[1] Previous to the receipt of this paper by the Editor, Mr. R. Etheridge, jun., had occasion to examine Mr. Swinton's figured specimen, contained in the British Museum Collection. Mr. Etheridge is convinced that not the slightest trace of any organ, as figured by Mr. Swinton (GEOL. MAG. Dec. II. 1874, Vol. I. Plate XIV. Fig. 3, "file"), exists on the specimen in question. The supposed "stridulating organ" is in fact only a fracture of the surface of the nodule, in which the wing is preserved. This is shown both on the fossil and its counterpart.—EDIT. GEOL. MAG.

is widely distinct from *Gryllacris*, which, on its side, has a neuration more widely allied to that of *Neuroptera* than, perhaps, any other group of *Neuroptera;* any comparison with other *Orthoptera* would therefore be still more vain, the neuration of the fossil wing bearing so much closer resemblance to that of those groups to which Audouin at first referred it.

Compared even with *Brodia*, it will be seen that the essential features of the neuration are the same, with the single exception of the mediastinal vein, which in *Brodia* ends on the margin not far from the middle of the wing; while in this ancient "*Corydalis*" it extends no doubt nearly or quite to the tip. But exactly such a difference as this is found to-day between *Raphidiidæ* and *Sialidæ*, and there can be little doubt that all four of the wings which have now been discovered (comprising all the important fragments of wings from the English Carboniferous rocks but one—a cockroach) belong to an ancient type of *Planipennian Neuroptera.*

Of these the two which are most nearly related to each other are, unquestionably, the *Corydalis Brongniarti* of Mantell and the *Lithomantis carbonaria* of Woodward. Indeed, the resemblance between them is so close that one would almost consider them as belonging to the same genus. The basal narrowness of the margino-mediastinal interspace, however, as well as the considerably greater importance of the internomedian area in *Lithomantis,* forbid this, though the course and general disposition of every principal vein is nearly identical.

Corydalis Brongniarti, then, being generically distinct from its synchronous allies, and widely different from living types, merits a distinctive name, and may be termed *Lithosialis*, to recall its relationship to the forms to which Audouin first compared it. From *Lithomantis* it differs in the points just mentioned; from *Brodia* in the basal breadth of the margino-mediastinal interspace, the much more numerous branching of all the lower veins, and the greater extent of the mediastinal, besides the more uniform breadth of the whole wing; from *Archæoptilus*, in the proportionally narrow area occupied at the base of the wing by the upper two interspaces, and the far later division of the externomedian vein.

Objection would perhaps be made by some to the retention of Woodward's name of *Lithomantis* for an insect whose supposed resemblance to the *Mantidæ* is found to be erroneous, and which does not even fall within the suborder to which the *Mantidæ* belong; but, aside from the fact that it belonged to an age when the characteristic features of *Orthoptera* and *Neuroptera* were more or less blended, its outward aspect is at first glance by no means very different from the insect to which Woodward has compared it; and the retention of the name has an historic interest which should not be disregarded; the number of Palæozoic insects is not, and is not likely to become, so great as to render the name itself an obstacle to a knowledge and easy recollection of its true affinities.

The following list contains the British Carboniferous hexapod insects discovered up to this time.

NEUROPTERA.

1. *Lithosialis Brongniarti* (supra).
    - *Corydalis* (allied to), Audouin, Ann. Soc. Entom. France, vol. ii. pp. vii and viii.
    - *Corydalis Brongniarti*, Mantell, Med. Cr. 2nd ed. lign. 124, fig. 2.
    - *Gryllacris* (*Corydalis*) *Brongniarti*, Swinton, GEOL. MAG. Dec. II. Vol. I. Pl. XIV. Fig. 3.
    - *Gryllacris* (*Corydalis*) *Brongniarti*, Woodward, Quart. Journ. Geol. Soc. Lond. vol. xxxii. pl. ix. fig. 2.

    Coalbrook Dale, Shropshire.

2. *Lithomantis carbonarius*, Woodward, Quart. Journ. Geol. Soc. Lond. vol. xxxii. pl. ix. fig. 1. Scotland.
3. *Archæoptilus ingens* (supra), near Chesterfield, between Shelton and Clay Lane. Derbyshire.
4. *Brodia priscotincta* (supra). Tipton, Staffordshire.

ORTHOPTERA.

1. *Etoblattina mantidioides*, Scudder, Pal. Cockroaches, pl. iii. fig. 3.
    - *Blattina* sp., Kirkby, GEOL. MAG. Vol. IV. Pl. XVII. Fig. 6.
    - *Blattidium mantidioides*, Goldenberg, Fauna Sar. Foss. vol. ii. p. 20.

    Claxheugh, Durham. An indeterminate fragment of another wing, perhaps of the same species, is mentioned and figured by Kirkby, in the same place.

2. *Phasmidæ*, sp. Kirkby, GEOL. MAG. Vol. IV. Pl. XVII. Fig. 8.

COLEOPTERA.

1. *Curculioides Ansticii*, Buckland, Geology, pl. xlvi. fig. 1. Coalbrook Dale, Shropshire.

The other species described by Buckland as a beetle has been shown by Woodward to be an *Arachnid*.

A more extended paper on the insects discussed here will appear, with a plate, in the Memoirs of the Boston Society of Natural History.

IV.—PROFESSOR CARL VOGT ON THE *ARCHÆOPTERYX*.

By PROF. H. G. SEELEY, F.R.S., etc.

IN the *Revue Scientifique* for the 13th of September, 1879, Professor Carl Vogt published a remarkable article on the *Archæopteryx*. This Memoir being in a periodical that would not come under the notice of all readers in this country, an excellent translation of the paper was published in the *Ibis*. It is difficult, if not indeed somewhat unhandsome, to criticize Carl Vogt's contribution; seeing that it makes known the famous second skeleton of *Archæopteryx*, which had long evaded all efforts to learn its characters. The present writer followed it from Solenhofen, in its migrations over Germany, only to find it guarded like a sacred mystery in the house of Otto Volger, in Frankfort. But while very difficult, from not having seen the specimen, for me to speak with any confidence on points of the anatomy of *Archæopteryx* in which Carl Vogt's conclusions may be open to discussion, it is much easier, and, indeed, almost a pleasant duty, to differ from him emphatically in the philosophical conclusions drawn from his study of the slab. And I here offer a few remarks, since the like have not been volunteered from any one more competent to speak on the subject, concerning reasons why naturalists should at least hold their judgment in suspense before adopting some of the learned Professor's new conclusions, and in the hope of elucidating the true nature of this singular fossil.

I will now proceed to give an abstract of the translation in the *Ibis,* with some comments.[1] The head is described by Vogt as small, pyramidal, with the top nearly flat, and the occiput obliquely truncated. The orbit is large, the nostril in front of it; there are two small sharp conical teeth at the end of the upper jaw. The author is uncertain whether the bone below the skull is the lower jaw or the hyoid bone. He remarks that what one sees of the specimen shows clearly that it is a true Reptile's head. On this point it is impossible not to wish that Professor Vogt had given reasons for his conclusion, for I fail altogether to recognize reptilian characters. If the skull is reptilian, what reptile does it resemble? or if there be no resemblance to any order of Reptilia in particular, what are the points of structure which show it to be reptilian? I fail to make out, either that the quadrate bone was blended with the skull, or that the post-frontal bone had the usual reptilian form; or that the skull possessed post-orbital arches such as often characterize reptiles. After the discovery that teeth may exist in the jaws in combination with typical bird structure, as demonstrated by Professor Marsh, we cannot rely alone on the teeth of *Archæopteryx* in evidence that the skull was reptilian. The skull is very different from that of *Hesperornis,* and altogether distinctive in the position of the eyes, below and in front of the brain-case; but in this there is nothing unusual in the bird class, and the whole post-orbital region seems to me to be altogether avian, and to display the convex osseous covering of the cerebral hemispheres, with a posterior compression and elevation of the skull into a ridge or crest above the region of the cerebellum. The circle of over-lapping eye-plates goes for nothing either way, nor can any inference be drawn from the position of the nostril. Therefore, while fully admitting "an elaborate study, requiring much time and care, would be needed to describe the bones of the head," it seems to me that Professor Vogt asks his readers to take his conclusions about the skull in faith as though he were the exponent of an infallible science; and this is exactly what we are forbidden by our belief in evolution to do.

The neck is stated to be as long as that of a pigeon of the same size; it is bent in the form of a horse-shoe, and is said to probably include eight vertebræ, furnished with free ribs. In form and proportion the vertebræ are avian, as are their ribs; which were probably united to the vertebræ. The author counts ten dorsal vertebræ, which are thick, short, as broad as high, and have no elevated neural spines. The dorsal ribs are fine, thin, curved, and

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[1] The Plate intended to accompany this notice not being available, a new one will be given next month.—Edit. Geol. Mag.

show no trace of uncinate processes. There are free sternal ribs, which the author supposes to have been fixed to an abdominal linear sternum. The pelvis, well shown in the British Museum specimen, is here said to be imbedded. Apparently its characters are altogether different from those displayed in the first slab, since the femora are in natural position; and the fore part of the sacrum, and apparently its hind part also, are laid bare without exposing any trace of the long ilium or of the other pelvic bones. The tail is very long.

The pectoral and pelvic arches next come under consideration. The author confesses to some doubt concerning the structure of the shoulder girdle, which is quite free from the body. Two long slender bones are directed backward; these are identified as scapulæ, and it is observed that they are formed nearly as in Pterodactyles and Birds. Between the slightly expanded anterior ends of the scapulæ is a bony mass which Professor Vogt regards as the coracoids. I should rather suspect that this median mass is the sternum, though in that case the coracoids remain unrecognized. This view Vogt has considered and rejected. There appears to me to be a groove on the anterior margin of this median mass, such as would contain the distal ends of the coracoids, and from the angle at which the coracoids probably met the scapula, they would naturally lie beneath those bones, and, if the mud were soft enough to receive them, would inevitably be squeezed into it. Unless we thus identify the sternum, there is confessedly here a fundamental difference of structure from the bird; but since the expanded feathers enforce the presumption that the fore-limb was used for flight, the conviction follows that flight was brought about by development of the pectoral muscles attached to a sternum in the usual way. This is the *à priori* view, and I see no evidence that the so-called coracoids have an osseous union with the scapulæ, or any reason for supposing that the coracoids would here be placed in a relation which has no parallel in birds, pterodactyles or bats. I cannot accept Vogt's interpretation, merely because such a relation of the coracoids as he suggests exists in some extinct orders of reptilia which did not fly. The probability is strong against finding an entirely new function for the coracoids in a flying animal. The interpretation reminds one in kind of the already considered interpretation of the skull: it may be excellent, but it requires excellent reasons in support before it can be received. There is a further point in which the shoulder girdle is supposed to be unlike that of most birds. Prof. Owen described in the original slab what he regarded as the furcula. This bone is absent, or at least not visible, in the second slab. It is sufficiently different from what might have been expected, to have often suggested some doubt as to its true nature; but we were scarcely prepared for Vogt's suggestion that it is the pubis. After quoting Prof. Owen's description of the pelvis of *Archæopteryx*, the author expresses a belief that Prof. Owen would not now formulate an opinion so positive as to its giving no evidence of reptilian structure, since we know the pelvis of Dinosaurs better, and know that it approximates towards birds. Far be it from me to pretend to know the hidden workings of another man's mind, but since the characters of the ilium of *Archæopteryx* have undergone no change in the mean time, it is only reasonable to infer that Professor Owen's ideas still remain what they were twenty years ago. Moreover, the pelvic region of *Archæopteryx*, so far as it is known, does not make the slightest approximation to that of a Dinosaur, and therefore the avian similitudes of the dinosaurian pelvis can, in the absence of fresh evidence, in no way influence our interpretation of the *Archæopteryx*. First, the bone in certain Pterodactyles which many writers have regarded as a pubis, and which has in some species a bow shape not unlike a furculum, is really the pre-pubic bone, a separate bony element from the pubis, as, I imagine, was demonstrated many years ago when I first suggested this name for it. Now this bone in its more ordinary divided form rather recalls marsupial bones of the mammal than any other structure; and in the dinosaurian pelvis the pre-pubic element is not separated from the pubis, and retains the condition seen in a less developed degree in birds, especially such birds as the *Apteryx*, in which I first noticed it, and the *Geococcyx*, in which it was recognized by Professor Marsh. Now, to suppose that this process, in those birds in which it can be recognized, is the remnant of the separate pre-pubic bone, or of the united pre-pubic bones of pterodactyles, is a supposition, in favour of which it would be hard to adduce anything. But certain difficulties of an *à priori* kind suggest themselves in the circumstance that the pelvis of the fossil was relatively narrow, and the spread of the supposed furculum is wide; that the bones of the pelvis of *Archæopteryx* are slender, while this bone is remarkably strong. I do not proceed to discuss the bone, because that ought to require an inspection of the second specimen; but its forward position on the slab, and the width between the free ends and the broad V-shape, seem sufficient justification for Professor Owen's interpretation. It therefore appears to me that the effort to set up reptilian affinities in the interpretation of this bone, and thus to detract from the avian character of the skeleton, is unwarranted by the facts. Having got rid of the clavicle and the sternum, it naturally follows that the author should compare the shoulder girdle of the *Archæopteryx* with that of the Crocodile; but this comparison, however delusive it may seem in presence of the woodcuts which are constructed to support it, fails altogether when we turn from diagrammatic figures to the crocodile skeleton on the one hand, and the photograph of the *Archæopteryx* on the other. It matters nothing to be told that the sternum disappears among Ichthyosaurs and Plesiosaurs, or that the coracoids meet in the middle line in those groups, or that some Plesiosaurs have no clavicles; the answer is obvious, that neither Ichthyosaurs nor Plesiosaurs are flying animals, and since function in each class governs the evolution of structure, it is obviously inconsequent to seek in a swimming type for structures which flight would develope. Professor Vogt comes to the conclusion that the shoulder girdle of *Archæopteryx* is that of a reptile, that the furcula and the sternum were non-existent, and that the form and arrangement of other bones is only paralleled by the structures of Enaliosaurs, Pterosaurs, and Crocodiles. I incline to conclusions exactly the reverse of these.

Proceeding with the examination of the fore-limb, it is remarked that the humerus with its flattened articular head offers some likeness to that of crocodiles. If we contrast the humerus, say of a very young Bramah fowl, with that of a crocodile, we become aware that it is possible for a bird to have a humerus more reptilian than that of the *Archæopteryx*, which certainly makes no obvious approach to the form of the bone in crocodiles. The bones of the fore-arm are remarked upon as having the ulna stouter than the radius, but otherwise offering no feature peculiar to either reptiles or birds. The carpus is stated to have been rightly determined by Prof. Owen as a single spherical bone. This the author compares to the single carpal of the Cassowary and *Apteryx*, but it is important to determine whether the carpal of the *Archæopteryx* is proximal or distal, since it is well known that the distal carpal of the bird becomes blended with the metacarpus early in life; hence it seems to me that there is room for further discussion of the bone. Turning to the hand, the author affirms that the manus of *Archæopteryx* can neither be compared to that of a bird nor that of a Pterosaur, but only to that of a tridactyle lizard. Prof. Owen assigned four digits to the manus, pointed out that there was no special elongation of a wing finger as in pterodactyles, and insisted on the ornithic proportions of the hand and mode of attachment of the quill feathers as evidence of a class affinity of *Archæopteryx.* In this fossil it is evident that there are three digits, similarly three digits exist in living birds, the metacarpal of the pollex is short exactly as in birds, the other two metacarpals are relatively long and of equal length, and the middle metacarpal is the stouter as in birds, and, so far as I can see, terminates proximally in a rounded carpal bone like that of a bird. The pollex has two phalanges, the second being a sharp claw, compressed from side to side, the other two digits have each three phalanges. The difference from living birds in primary structure consists chiefly in the development of the terminal claw to the pollex, the terminal claw to the middle digit, and a claw and a second phalange to the third digit. The author considers that the pollex was free, but of this there is little evidence. He compares the manus to that of *Compsognathus*, but the comparison cannot be sustained in detail when the structures are compared bone for bone; and it is further asserted that the manus of *Archæopteryx* cannot be compared with that of a bird. I have drawn attention to the points in which it resembles birds and in which it differs from them, but while those differences are remarkable as being of two kinds—(1) the absence of anchylosis in the metacarpals, and (2) the development of additional phalanges—these are not necessarily reptilian characters, because the conditions of life exhibit comparatively little variation of function for the extremities among living birds, and in the different orders of both higher and lower vertebrata a considerable range of variation is found in corresponding parts of the skeleton. The form and curvature of the femur and the modification of its proximal end is avian, the tibia is also avian, as is the fibula, which is reduced to a needle-like splint, anchylosed to it as in living birds and pterodactyles. The hind-foot, including the metatarsus, is avian. The author then sums up the facts with regard to the skeleton, and concludes that "the head, neck, thorax, ribs, tail, shoulder girdle, and whole fore-limb, are plainly constructed as in reptiles. The pelvis has probably more agreement with that of reptiles than with that of birds. The hind-foot is that of a bird. Reptilian affinities therefore prevail in the skeleton above all others."

This resurrection of the views of Wagner as enunciated on the discovery of the first *Archæopteryx* appears to result from the way in which the subject is approached. If *Archæopteryx* is a reptile, it is a subjective reptile created by Professor Vogt by means of theoretical considerations which can hardly be accepted without discussion; but the objective *Archæopteryx* seems to show nothing more reptilian than might have been anticipated in an extinct animal devoid of the latest specializations of osteology which have been developed in living birds, and have come therefore to be regarded as class characters, and probably as more important than they really are. It would have been a reversing of one of the oldest canons of natural history to find well-developed plumage associated with a reptilian skeleton. If the affirmation had been sustained, it would not have helped evolution in the least; for it would have interposed the anomaly that, with a skeleton alleged to be essentially reptilian, feathers as well developed as can be found in the existing class of birds coexisted. There would have been no transition here, but an incongruity greater than that of a less noble animal clothed in the skin of a lion. The feathers, too, are shown to be arranged as in birds, the wing in its outline is compared by the author to that of a fowl, "the remiges of the wing are fixed to the ulnar edge of the arm and to the manus, and covered for nearly half their length with a fine filiform down." It is thought that the base of the neck may perhaps have carried a ruff like that of a condor, but to me this seems more than doubtful. The tibia was clothed with feathers down the whole of its length, as in the falcons. Each caudal vertebra carried a pair of lateral retrices. All the rest of the body, the head, neck and trunk, are said to have been evidently naked and unprovided with feathers. To this last view, exception might fairly be taken, since the decomposition of the soft parts of the body would have carried with them the covering if such existed. Indeed, dead sea-birds on our shores often retain, when decomposition has advanced far, exactly the same feathers as are seen in this fossil.

The author concludes that the *Archæopteryx* can neither be ranked among reptiles nor birds, but that it forms a marked intermediate type. "Bird in its integument and feet, *Archæopteryx* is reptile in all the rest of its organization, and its structure can only be understood by admitting the evolution of birds by a progressive development from certain types of reptiles."

The second part of the paper is entirely theoretical; and is an argument designed to show the considerations which weigh with the author in his interpretation of *Archæopteryx*. He first shows that the vertical position does not imply flight, then that flight is independent of an upright position, next that adaptation to flight is seen in the shoulder girdle and in the proportions of the bones; flight is then considered, first by means of a membrane as in Pterodactyles, Flying-squirrels, and Bats, and secondly by means of feathers, so as to show how the skeleton is modified in each case. He remarks that the flight of the *Archæopteryx* may in some measure be compared with that of *Galeopithecus* among mammals, but that it is a step further forward in the march of adaptation. It is affirmed "that no naturalist on being shown the skeleton of *Archæopteryx*, alone and without the feathers, could suspect that this animal had been in its lifetime furnished with wings." For it is observed that if "we could for a moment remove all the feathers we should have before our eyes the tridactyl manus of a Reptile. And yet it is added, "The number of digits and the single carpal depart from the normal structure of Reptiles. The digits, without doubt, are altogether of the most decidedly reptilian conformation; but they are reduced to the normal number possessed by Birds, and the middle digit is the longest of the three." This is Vogt's view. At the beginning of the argument the animal is reptilian; at the end the bird is becoming evolved. I have a suspicion that the skeleton is far from suggesting that the animal was destitute of wings; for the only characters which could promote such a doubt are the unanchylosed condition of the metacarpal bones and the claws. The former point is a difference from birds, but in my view much less important than a difference of osteological plan would have been, and no more important than the persistence of separate epiphyses, or cranial sutures. That the skeleton in existing birds happened to have its distinctive structure of the manus is, I suppose, an accident consequent upon the way in which the wing feathers came to be developed so as to affect the vascular system and ossification. I believe it will be found convenient, on the hypothesis that the feathers are the main cause of specialization in the bird, to define an animal as being a bird so soon as it possesses the avian plumage, because the vital organization could experience no important change from this cause which might not as well have been developed by wings of the Ornithosaurian type.

The author then proceeds to discuss the affinities of *Archæopteryx*, remarking that the Cretaceous birds, so well described by Professor Marsh, form a further indication of the course of Avian evolution, since, "except some secondary points in the structure of their vertebræ, their only Reptilian character is the presence of teeth in both their jaws." The gap, however, between the Odontornithes and *Archæopteryx* is confessedly very great. He is unable to unite *Compsognathus* with *Archæopteryx*, as Prof. Gegenbaur has done, or to see in it an ancestor of the bird, because it has no trace of feathers, has very short fore feet, and hind feet formed like those of reptiles. An equal difficulty is felt in regarding the Dinosauria as the ancestors of the whole bird class. And, without undervaluing the avian similitudes of Dinosaurs, the author believes that "all the characters whereon are based the claim of Dinosaurs to be regarded as the ancestors of Birds are only related to the power of keeping an upright position upon the hind feet." This is too large a subject to enter into now, for it involves the whole question of how far persistent function, when identical in character, may develope in allied groups of animals nearly identical structures. Vogt believes that certain Dinosaurs were leaping or perching animals, and infers that the avian characters of the pelvis and hind-limb thus came to be evolved from community of habit with birds. He is, however, not indisposed to see in Dinosaurs possible parents of the Ratites; while the *Archæopteryx* would be the ancestor of the Birds that fly. The bird class, however, seems to me remarkably homogeneous in vital structures, and also in such characteristics of the skeleton as are common to the class.

In this view Struthious birds, far from being a degenerate group which had lost their wings, would be a primitive group which had not reached active flight. But the *Ratitæ* have far too much in common with carinate birds to permit a suspicion that they have originated in a fundamentally different way from a different stock. The Dinosaurs are far too diverse to permit a suspicion that they are the direct ancestors of any Birds. The dinosaurian armour is about the last thing in the world that would suggest feathers, and it is difficult to conceive of any advantage in the struggle for existence which would lead to Dinosaurs becoming feathered, if the feather were not developed into an organ of flight. It is true that many Dinosaurs may have been naked, but that does not justify us in presuming that the skin contained the germ plan of the ostrich feather, which time would inevitably develope. Still less is there anything in Dinosaurian structure to suggest that the saddle-shaped intervertebral articulation of the centrum in a Struthious bird would spring into existence side by side with the same structure in the vertebral column of a carinate bird, if the latter had been derived from a fundamentally different stock.

While Vogt thus regards the two existing groups of birds as having ancestral representatives in the Jurassic rocks, no evidence is detected of a common ancestor. It is, perhaps, remarkable that in this discussion the Pterodactyles are omitted from comparison with the *Archæopteryx*. There are, however, some points remarked upon in the earlier portion of the memoir which may be here noticed. This skeleton is said to show no trace of a pneumatic structure, thus differing from Pterodactyles. I cannot quite agree with Prof. Vogt when he affirms that Pterosaurs were never able to hold themselves upright as do birds, because their hind-feet were very weak, short, and furnished with slender digits. It might be well to study the skeleton of the original *Pterodactylus longirostris* figured by Cuvier and many others, or, if this were too small, the *Dimorphodon macronyx* from the Lias would show an animal well capable of walking in the position of a bird, while the *Cycnorhamphus suevicus*, at Tübingen, and the similar skeleton at Stuttgart, are both examples of Pterodactyles with long hind-legs. Certain other Ornithosaurs have the hind-limbs relatively small, but it is open to consideration whether flight may not have attained its development in those animals after the vertical position of body had been acquired. It might be as well also to recognize that there is no published evidence of fundamental difference in the hand between Pterodactyles and Birds such as Prof. Vogt represents. Omitting for the moment the evidence that *Ornithocheirus* from the Cambridge Greensand had three digits, saying nothing about the embryological evidence as to primitive indications of four digits in the manus of the bird, it may be laid down once for all that the restorations which give the Pterodactyles five digits in the hand belong to a prehistoric period. Oken, Wagler, and Goldfuss, it is true, thought there were five digits, and the restoration of the latter writer has been frequently reproduced, but no specimen could ever be found in support of such an interpretation, and it has long since been abandoned by every one pretending to draw his knowledge from specimens. It is therefore astonishing to see a figure given of the fore-limb of *Rhamphorhynchus* in which there are four clawed digits. One cannot but ask where the specimen is to be seen which shows the structure of fore-limb depicted in Prof. Vogt's figure. If the figure is faithfully copied from the photograph to which Prof. Vogt refers as of *Rhamphorhynchus gemmingii*, it certainly belongs to a new and undescribed type of Ornithosaur. The *Archæopteryx* is in no respect a modified Pterodactyle; but it has enough in common with the Pterodactyles to make that group in some respects better illustrative of its skeletal structures than Dinosaurs.

Finally the Professor considers the influence of the feathers in changing the skeleton of a reptile into that of a bird, suggesting that the ancestors of the bird were scaly lizards. Briefly it is the author's view that modification of organization proceeds from "the skin to the skeleton," and that the latter may be wholly unaffected when the former has already reached the development of feathers. Now this view renders the position taken up by Vogt perfectly logical, but the view itself is, as a general principle, not so obviously logical, because it is shown by the existence of other flying animals that flight itself does not necessarily change an animal's grade of organization. If the *Archæopteryx* were the modified reptile that it is assumed to be, the development of feathers might tend towards an avian modification of the manus, but not inevitably, since the clawed condition persists in one digit in the bat, as well as in several in the Ornithosauria. No doubt the development of feathers was correlated with an important modifying influence on the extremities of the skeleton in the bird; but the feathers themselves must be presumed to have been slowly evolved, and from their first existence must have tended to modify muscles in ways that would have contributed to change the skeleton, so that I cannot conceive of the existence of well-developed plumage without a correlative modification of the skeleton.

In the absence of the specimen, it were perhaps wiser to rest in the conviction that *Archæopteryx* is a Bird, less modified in structure in the direction which existing avian osteology has taken, and therefore more easily comparable with reptiles; but not necessarily more reptilian, or of inferior organic grade to the newer bird type. Certainly the time has not come when we can assemble a jury of its inferior kith and kindred, and accept such verdict as they may suggest concerning its genesis. For the osteological structures which are universal in living birds, and from which the *Archæopteryx* departs, are independent of affinity, and among mammals would not rank as of much importance. If the *Archæopteryx* do no more than teach us to extend our conception of the limits within which a bird's skeleton may range, it will have enriched science with morphological knowledge, which is invaluable in its theoretical bearings.

V.—THE SUDDEN EXTINCTION OF THE MAMMOTH.

By HENRY H. HOWORTH, F.S.A.

IN a previous paper[1] I urged that the conclusions there arrived at necessitated certain corollaries which are not universally accepted, and to which I hoped to call attention in the future. One of these I now venture to shortly discuss.

We have tried to focus the facts about the Mammoth which go to show that its surroundings and mode of life were the same from Central Europe to Behring's Straits; that when we examine the position candidly and completely, there is no room for hypotheses requiring an annual migration of the Mammoth and his contemporaries from North to South and *vice versâ* with the seasons as some have urged; that the view almost universally held now by Continental and especially Russian palæontologists, that the Mammoth lived all the year round where its remains are still found, is amply justified; and lastly, that all the evidence goes to show that when the Mammoth lived along the borders of the Arctic Sea in Siberia in great numbers, the climate of that area was a comparatively temperate one, and that its more equable character enabled animals and plants, which are now the inhabitants of a more northern and a more southern latitude respectively, to live together under more neutral conditions. These conclusions being granted, it follows. as at least an *à priori* probability, that the causes of the extinction of the Mammoth and his companions—a problem of the highest scientific as well as of singularly romantic interest—were the same throughout.

We cannot help saying *in limine*, that it is a pity that English writers on Post-Glacial geology should so often have based very wide and far-reaching inductions upon facts collected in such a narrow area as that embraced within our four seas. Not only is the field very narrow, but also very misleading. Great Britain is an area where during the period of the Mammoth two contrasted zoological and botanical provinces met and overlapped. The typical fauna and flora characteristic of the vast Siberian plains where the Mammoth chiefly flourished were here mixed with, and dovetailed into, another

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[1] GEOL. MAG. 1881, p. 256.

fauna and flora, whose focus was the Mediterranean and its borders, and thus the solution of the main problem is here complicated by subsidiary difficulties.

Again, Great Britain is marked geologically by an exceedingly broken and dislocated character. This character has no doubt laid bare and disclosed the secrets of its history in a way which is hardly to be matched elsewhere; but this very fact makes it unsafe to deduce a wide generalization from the local and often sophisticated evidence which it furnishes. For purposes of generalization it is safer and more prudent to sift our evidence when there has been the smallest possible after-dislocation and sophistication. If this be a wise method,—and we take it the question is scarcely arguable,—then it is assuredly the most scientific plan to put Britain and Western Europe aside for a while, and to concentrate our attention upon Siberia; and when we have found a clue to solve our riddle there, to return with it and explain what is apparently a difficulty nearer home.

The problem in the present instance peculiarly invites this method of solution, inasmuch as in Northern Siberia the changes which have passed over the country since the disappearance of the Mammoth have been so slight that the soft tissues of the animal have been preserved intact, while in Britain we for the most part only meet with its scattered *débris.*

The question we would ask in these few pages is, What is involved in, and necessarily follows from, the preservation of whole bodies of Mammoths, with their flesh and other tissues preserved for ages without decay? The question, however awkward it always sounds to the ears of those who have accepted in its integrity the creed of Uniformity, should clearly not be evaded and left completely unanswered, as it has been in nearly every modern discussion on the period of the Mammoth. We are bound to candidly look it in the face, untrammelled by *à priori* prejudices and unbiassed by the particular creed which may be current in a popular school of inquiry. Let us try with due deference to face the difficulty fairly.

The first thing that seems to follow inevitably from the facts is, that the bodies which are now found intact in the Siberian tundras have remained frozen since they were first entombed. If they had been subject to alternate congelation and melting with the intermittent seasons, they would assuredly have long since decayed. An exposure to one summer's sun, to one season's melting, would have induced putrefaction and dissipation. We are not dealing here with animal substances deposited in bogs, and changed into such organic compounds as adipocere, but of flesh so unchanged that it has all the characters of that of animals which have recently died, when examined under the microscope, while it is readily eaten by the wild animals that live on the tundra. The flesh is as fresh as if recently taken out of an Esquimaux cache or a Yakut subterranean meat-safe. There cannot be a moment's doubt that this condition was secured by one cause, and one cause only, namely, that since the bodies were entombed they have been in a state of continuous congelation without a break.

This is assuredly the only possible conclusion. It is one which I have urged at different times before the Geological Society, the British Association, and personally to several of my geological friends, of experience much wider in this field of inquiry than my own; and on all occasions there has been a consensus that what is here urged is inevitable. It is amply supported by other facts; thus, the northern part of Siberia is at this moment, and has been so far back as our historical records reach, permanently frozen at a few feet from the surface. Below a mere cuticular thawing in the summer, the ground is permanently frozen. About this, which has been doubted by one famous geologist, before whom the problem has been placed, the evidence is complete and overwhelming. Let us see.

Erman's admirable work on Siberia is an authority beyond question. He says he was assured, when at Yakutsk, on the Lena, that frozen earth is there found near the surface at every season of the year, and that the same condition of the ground continues to the greatest depth hitherto reached. He then goes on to quote an experiment which had recently been made on a large scale, which was quite conclusive of the point. He says Mr. Shergin, who was at the head of the establishment belonging to the American Trade Company, had much desired to have a well within his inclosure, while the other inhabitants of Yakutsk supplied themselves with water in summer from the Lena, and in winter by melting snow. He was at the same time quite convinced of the perpetual congelation of the ground, but still hoped to succeed, if the wells could be only dug as deep as they usually are in the governments of Vladimir and Nijni Novgorod. The work was begun at the beginning of summer, and continued without interruption to a depth of forty-two feet. But at that time—the warmest part of the year—the strata of fine sand and clays which formed the sides of the shaft were found to be uniformly frozen hard, so that, instead of digging with the spade, it was found necessary to have recourse to the miner's pickaxe. The flakes and frozen pieces of earth in the interior of the well seemed perfectly dry, and they had to be carried up into the warm air and thawed before they gave any signs of moisture. Erman himself descended into the well when it had reached the depth of fifty feet, and buried a thermometer in the ground at the bottom, but never saw the mercury rise above —6° R.; and supposing that the increase of heat from the surface to the centre of the earth is as rapid from this point downwards as in other places, we should not expect, he says, to find water in the fluid state till we arrive at the depth of 630 feet, for to that depth the ground is frozen (*op. cit.* vol. ii. pp. 366–367). Speaking of Aldansk, on the River Aldan, Erman says that the people there told him that even in the warmest months, under sandy soil, and often at a depth of only six feet, layers of solid and transparent ice are found alternating with frozen and dry earth. "This is the same phenomenon," he says, "which I saw near Yakutsk, on the banks of the Lena, and which is also found on the islands in the Icy Sea" (*id.* p. 423).

Again, speaking of the crops sown about Yakutsk, he says:—"Summer wheat and rye are sown by the Russians in the neighbourhood of the towns. These fields are at that time thawed to a depth of three feet; they rest on perpetually frozen strata, etc." (*id.* vol. ii. p. 370). The Yakuts, it is well known, take advantage of this condition of the ground, and by merely digging pits in it they form at once permanent ice-houses or meat-safes. This state of things is not limited to the valley of the Lena, but is found all over Northern Siberia where the bodies of Mammoths occur. Thus we read of the tundras about the Obi that their soil is always frozen, not even in the middle of summer thawing beyond 13 inches in depth (Wrangell's Voyage, tr. by Sabine, p. lii).

Similarly, Wrangell describes the soil a few inches below the surface as perpetually frozen at the other end of the continent, in the neighbourhood of Kolymsk and the peninsula of Chukchi (*op. cit.* pp. 39, 50–51, 276). While speaking of the cliff facing the Polar Sea, he says:—"It consists in great measure of ice which never thaws, mixed with a little black earth and clay, amongst which are a few long thin roots of trees." He speaks of another part of the coast as consisting of ice, clay and black earth, out of which he drew some of the interspersed roots, and found them chiefly birch, and as fresh as if just severed from the trees, the nearest woods being 100 versts off (*id.* pp. 223–224). I have quoted these supporting facts, but it was hardly necessary. The very distinguished writer against whose conclusions this paper is really directed, "Our father Permenides," Sir Charles Lyell, admits so much without question. "It is certain," he says, "that from the moment when the carcases both of the Rhinoceros and the Elephant above described were buried in Siberia in lat. 64° and 70° N., the soil must have remained frozen, and the atmosphere as cold as at this day" (Principles of Geology, vol. i. p. 183). Again, "One thing is clear, that the ice or congealed mud in which the bodies of such quadrupeds were enveloped has never once been melted since the day when they perished, so as to allow the free percolation of water through the matrix; for had this been the case, the soft parts of the animals could not have remained undecomposed" (*id.* p. 184).

So far then we may take it there is no dispute, and the matter may be treated as "res judicata."

At this point, however, we claim leave to completely diverge from the current opinion in England. We should do so with greater anxiety if, after we had reached our conclusion by an independent induction, we had not found that it was the deliberate view to which Cuvier and Buckland long ago came, and which has been more recently urged by such an experienced geologist as M. d'Archiac.

We have shown at some length in a previous paper that the Mammoth and his companions could not live under the conditions which now prevail in Northern Siberia. This is frankly admitted by Lyell. He says, "It would, doubtless, be impossible for herds of Mammoths and Rhinoceroses to subsist at present throughout the year even in the southern part of Siberia, covered as it is with snow during the winter." He then goes on to say, "But there is no difficulty in supposing a vegetation capable of nourishing these great quadrupeds to have once flourished between the latitudes of 60° and 65° N." He then postulates the actual existence of such a zone in Siberia, and goes on to argue that the carcases of Mammoths found along the borders of the Polar Sea reached there either by being floated down the rivers or were summer migrants caught by the ice. This view is assuredly obsolete.[1] As I have said before, among the continental authorities there is now but one view held, namely, that there were neither seasonal migrations nor were the bodies thus transported, but that the fauna whose remains are found in such profusion along the Arctic Sea lived where their remains are found, and lived there all the year round.

If Lyell's explanations are not accepted, we are driven apparently by a process of exhaustion, not only to the conclusion that when the Mammoth lived in Siberia his surroundings were entirely different from those which now prevail there, but also that the change to the present state of things must have taken place *suddenly* and *per saltem.* While it is on the one hand clear that the ground in which the bodies are found has been hard frozen since the carcases were entombed, it is no less inevitable that when these same carcases were originally entombed, the ground must have been soft and unfrozen. You cannot thrust soft flesh into hard frozen earth without destroying it. Great carcases of Mammoths with the most delicate tissues, the eyes, the trunk, the feet, beautifully perfect, cannot have been forced down into ground consisting of alternate layers of ice and frozen earth. Such a process is physically impossible.

It has been jauntily argued that the Mammoths were engulphed in the great Siberian rivers and then frozen fast in the ice accumulated along their course; but in the first place, as has been frequently shown, the carcases do not occur in ice at all, but in frozen earth, and secondly, they do not chiefly occur along the river-courses, nor do they occur chiefly in the marshy, boggy land where others have postulated the suffocation of the animals, but, as Lyell himself says, they are chiefly found "where the banks of the rivers present lofty precipices of sand and clay, from which circumstance Pallas very justly observed, that if sections could be obtained, similar bones might be found in all the elevated lands intervening between the great rivers. Strahlenberg, indeed, had stated before the time of Pallas, that whenever any of the great rivers overflowed and cut out fresh channels during floods, more fossil remains of the same kind were invariably disclosed."—Lyell's Principles, etc., ed. 1872, vol. i. pp. 179–180. Even if they did chiefly occur in the river-beds and marshes, the necessity for an immediate congelation of previously soft ground still remains.

Looked at in every view, the judicial conclusion of Cuvier, which has been laid aside for many years on account of Sir Charles Lyell's supposed reply, is unassailable; and the longer one studies the question, the more one is impressed with the truth of the judgment.

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[1] We think not quite obsolete.—Edit. Geol. Mag.

His words are as follows: "Tout rend donc extremement probable que les elephans qui ont fourni les os fossiles habitoient et vivoient dans les pays où l'on trouve aujourd'hui leurs ossemens.

"Ils non pu y disparaitre que par une revolution qui a fait perir tous les individus existans alors, ou par un changement de climat qui les a empêche de s'y propager.

"*Mais quelle qu'ait été cette cause, elle a du être subite; des os et l'ivoire si parfaitement conservés dans les plaines de la Siberie, ne le sont que par le froid qui les y congêle, ou qui en general arréte l'action des elemens sur eux. Si ce froid n'etoit arrive que par degres et avec lenteur, ces ossemens et a plus forte raison les parties molles dont ils sont encore quelquefois enveloppés, auroient eu le temps de se decomposer comme ceux que l'on trouve dans les pays chauds et tempérés.*

"*Il auroit surtout bien impossible qu'un cadavre tout entier, tel que celui que M. Adams a decouvert eut conserve ses chairs et sa peau sans corruption s'il n'avoit été enveloppé immediatement par les glaces qui nous l'ont conservé. Ainsi toutes les hypotheses d'un refroidissement graduel de la terre ou d'une variation lente soit dans l'inclinaison soit dans la position de l'axe du globe, tombent d'elles-mêmes.*"—Cuvier, Ossemens Fossiles, 1821, vol. i. p. 203.

Dr. Buckland says:—"One thing however is certain as to this Mammoth (*i.e.* Adams's), that whether it was imbedded in a matrix of pure ice or of frozen earth, it must have been rapidly and totally enveloped in that matrix before its flesh had undergone decay, and that, whatever may have been the climate of the coast of Siberia in antecedent times, not only was it intensely cold within a few days after the Mammoth perished, but it has also continued cold from that time to the present hour" (Appendix to Beechey's Voyage, p. 608).

I will quote in conclusion another writer, whose words will be received with the respect due to their distinguished author, the experienced French geologist, M. d'Archiac. In discussing the causes of the destruction of the Mammoth, he says, and I again prefer to quote his exact words:—"Mais une autre circonstance, qui a du accompagner ou suivre de très prés le phénomène tel qu'il soit (he is referring to the phenomenon which caused the destruction of the Mammoth), *c'est un abaissement rapide de la température, tel que la décomposition des chairs et des autres parties molles ait été prévenue, dans un grand nombre de cas. Il a fallu, de plus, que cette température ne se soit jamais relevée ensuite pour faire dégeler ce sol glacé, qui nous a ainsi conservé presque entiers les animaux enselevis depuis tant de siècles*" (D'Archiac, Leçons sur la Faune Quaternaire, p. 172).

As I said, this conclusion I arrived at independently, and before seeing any of the statements just quoted, and I quote them as showing that the views here urged are not new, but constitute a reversion to a sound conclusion arrived at long ago by experienced observers, and only disturbed by the fascinating arguments of Sir Charles Lyell. The doctrine of Uniformity has done ample service in Geology, but its cause has been urged so exclusively, and to such extreme limits (as is best testified in the address of the last President of the British Association), that it is not strange that there should be a tendency in the pendulum to return to a more normal position. In the present case, at all events, there does not seem to be room for doubt that a sudden and widespread change of climate took place over the whole breadth of Northern Siberia at the time of the final extinction of the Mammoth. This conclusion is not the only one which seems to follow inevitably from the facts; but we must reserve any further development of the position for another communication.

VI.—NOTES ON THE VERTEBRATA OF THE PRE-GLACIAL FOREST BED SERIES OF THE EAST OF ENGLAND.

By E. T. NEWTON, F.G.S.

PART V.—PROBOSCIDEA AND CETACEA.

THE following list includes all the species belonging to these two groups which have hitherto been recorded from the "Forest Bed Series."

PROBOSCIDEA AND CETACEA SAID TO HAVE BEEN FOUND IN THE "FOREST BED SERIES." (See also corrected list, at p. 317.)

Elephas antiquus.
  ,, *priscus.*
  ,, *meridionalis.*
  ,, *primigenius.*
  ,, *leptodon* (Gunn, MS.)
  ,, *giganteus* (Gunn, MS.)
Balæna or *Balænoptera*, two species.
Narwhale.

PROBOSCIDEA.

Elephas.—The remains of Elephants have been found in considerable numbers in the "Forest Bed" deposits, and consist chiefly of isolated teeth, although several jaws with the teeth in place, and some enormous limb-bones, have likewise been obtained. The latter are notable objects in the Norwich Museum and some private collections. Until the investigations of Dr. Falconer, all these Elephant remains were referred to the one species, *E. primigenius*; but he showed that there were at least two other species, which would have to be separately recorded, namely, *E. antiquus* and *E. meridionalis* (Palæon. Memoirs, 1868, vol. ii.). The occurrence of the last two species has never since been called in question; but such is not the case with regard to the *E. primigenius*, for there has been much discussion about the antiquity of this species, and regarding its Preglacial origin. At the present time our best authorities seem to be satisfied that the *E. primigenius* does occur in the "Forest Bed"; or at least that a variety, which cannot be definitely separated from the species, has been obtained from this horizon. This form most nearly resembles the coarse-plated molars of *E. primigenius* which are found at Ilford. Dr. Leith Adams, who has paid so much attention to the fossil Elephants, refers all the "Forest Bed" forms at present known to three species, namely, *E. antiquus*, *E. meridionalis*, and *E. primigenius*, the numerous intermediate varieties, which to a great extent bridge over the intervals between these, being looked upon as varieties of one or other of them.

To *Elephas antiquus* are referred those comparatively narrow-crowned molars, with wide plates of enamel more or less enlarged in the middle, the enamel of which is thick and much crenulated. This typical form occupies as it were a central position in the species, and variation takes place in two directions. In the first the enamel plates expand from before backwards, and when the tooth is much worn, especially when worn very obliquely, the spaces are so wide as to resemble much the Loxodon type of tooth. This form was referred by Dr. Falconer to *E. priscus*, but he afterwards came to regard it as an extreme variety of *E. antiquus*. The second or "broad-crowned" variety has the plates of enamel flattened and nearer together, the enamel also in some cases being thinner and less crenulated. The extreme examples of this variety approach so near to those molars which are said to be the "Forest Bed" representatives of the Mammoth that it is not always clear to which they should be referred. In fact, there is every gradation of form between the two species.

To the species *E. meridionalis* are referred those massive molars which are characterized by having very low crowns in proportion to their great width, the enamel plates thick and widely separated, and the enamel itself very thick and smooth, with little or no crenulation. Varieties of this form seem to connect the species with *E. antiquus*. Mr. Gunn is of opinion that certain of these varieties, between the three species above mentioned, should be elevated to the rank of species, and he has proposed the names of *E. leptodon* and *E. giganteus* for two of them. At present, however, these species have not been defined, and Dr. Leith Adams, after long study, thinks it best to look upon them merely as varieties. With the opinion of the latter gentleman I feel constrained to agree, and to acknowledge with him only three species of *Elephas* in the "Forest Bed," namely, *E. antiquus*, *E. meridionalis*, and *E. primigenius*. At the same time it should be remembered that the latter species is represented by a somewhat extreme form which may eventually have to be regarded as distinct.

CETACEA.

Balænoptera?—Some very large Cetacean vertebræ from the "Forest Bed" at Mundesley and Bacton are preserved in Mr. Gunn's Collection at the Norwich Museum. Sir C. Lyell referred to these in 1863, as representatives of *Balænoptera* (Antiquity of Man, p. 216), and Mr. Gunn, in 1864, considered that they belonged to "two species of Whales" (Geol. Norfolk). The centrum of the largest has a diameter of about 15 inches. It is not easy to say to which of the larger whales these vertebræ belong, but on the whole it seems most probable that they belong to the largest form, namely, the Fin Whales or *Balænoptera*, and with some doubt it will be best to place them in this genus without attempting any closer determination.

Monodon monoceros.—The earliest notice of the occurrence of the Narwhale in the "Forest Bed" is in Sir C. Lyell's Antiquity of

Man (1863, p. 217), and most probably, the specimen on which this rested was the one said by Mr. Gunn to be from the "Laminated Beds" at Mundesley (Geol. Norfolk, 1864), and now preserved in the Norwich Museum. This specimen is a fragment of a tusk about five and a half inches long, and one and a half inch in diameter, showing the very characteristic twisted condition so distinctive of the tusk of this species.

Delphinus delphis ?—Mr. A. Savin, of Cromer, has in his Collection four small Cetacean vertebræ from the "Forest Bed" of Overstrand, near Cromer. One of these is a middle caudal vertebra, which agrees so precisely with a corresponding vertebra in the tail of a common Dolphin that there can be little doubt as to its belonging to that species; but seeing that in other species these vertebræ are very similar, it seems best to place a note of interrogation after the species. The terminal epiphyses of this vertebra are firmly anchylosed to the centrum, the greatest antero-posterior extent of which is about 1·0 inch, its greatest width 1·4 inch, and its height without neural spine 1·6 inch.

Delphinus, large species.—The only other vertebra of the four, above mentioned, which is in a condition for comparison, is likewise from the caudal region, but from a more anterior position. Its terminal epiphyses are wanting, never having been anchylosed. The antero-posterior extent of the centrum is in its present condition about 1·3 inch, its height and width being each about two inches. In form this vertebra closely resembles the one referred to *Delphinus delphis*, but its larger size corresponds better with the skeleton of *D. tursio* preserved in the Royal Coll. Surg. Museum; the agreement in form, however, is not sufficiently close to justify one in referring it to that species.

CORRECTED LIST OF THE PROBOSCIDEA AND CETACEA FROM THE "FOREST BED SERIES." (Those marked with an asterisk * are new to the "Forest Bed Series.")

Elephas antiquus, Falc.
——— *meridionalis*, Nesti.
——— *primigenius*, Blumb.
Balænoptera ?

Monodon monoceros, Linn.
**Delphinus delphis*, Linn.
**Delphinus*, sp. (large).

VII.—MATERIALS FOR THE CORRELATION OF THE LOWER PALÆOZOIC ROCKS OF BRITAIN AND SCANDINAVIA.

By CHARLES LAPWORTH, F.G.S., etc.,

Professor of Geology and Mineralogy, Mason Science College, Birmingham.

(*Concluded from p.* 266.)

Cambrian of Westrogothia, Oland, etc.—The Cambrian Rocks are shown in several other localities in Scania. The basal sandstones (Lugnas or Eophyton sandstones) near the Baltic coast, near Delperöd. The *Hardeberga sandstones* (Fucoid Sandstone) are found wherever the Archæan is bared, as near Rostånga, Lund, Eljaröd, and Cimbrishavn. Sections of the Alum schists are rarer. The most perfect is that of Kiviks Esperöd on the Baltic, where the *Coronatus* Limestone or *Exsulans* horizon of the *Parad. Tessini* zone well develop ed. The identity between its palæontological sequence and that of Andrarum was demonstrated by Nathorst in 1876.[1]

The Hardeberga Sandstone is found also in the island of Bornholm, and the *Paradoxidian* zones of *P. Tessini*, *Par. Davidis*, and *Par. Forchhammeri*, each zone agreeing in position and in fossils with its counterpart at Andrarum.[2] In Westrogothia, the basal Sandstones and the Alum schists are both well developed. The former include both the Eophyton and Fucoid sandstones, and the latter their two natural divisions of *Paradoxidian* and *Olenidian*.[3] Even as early as 1876,[4] before the correct sequence of the Andrarum fossils had been ascertained, Linnarsson recognized the following palæontological subdivisions in the Alum schists of this region.[5]

a. Upper Groups, *Regio Olenorum* (*Olenidian*).
  Division 5, with *Olenus* (*Peltura*) *scarabeoides.*
    ,, *alatus.*
  Division 4. Beds with *Olenus latus*, *Olenus* (*Parabolina*) *spinulosus*, Wahl., *Agnostus pisiformis*, Linn., and *Olenus gibbosus*, Wahl.
b. Lower Groups. *Regio Conocorypharum* (*Paradoxidian*).
  Division 3. Beds with *Liostracus costatus*, Ang., etc., *Agnostus lævigatus*, Dalm., *Orthis* and *Lingula.*
  Division 2. Beds with *Paradoxides Forchhammeri* (?), *Arionellus difformis*, Ang., *Anomocare* sp., *Conocoryphe*, and *Obolella.*
  Division 1. Beds with *Paradoxides Tessini*, *Liostracus aculeatus*, Ang., *Agnostus parvifrons*, Linn., *A. gibbus*, Linnrs., *A. fallax*, Linnrs.

Divisions 5 and 4 correspond most distinctly to the zones of *Peltura scarabeoides* (*b*), and *Parabolina spinulosa* (4), of the *Olenidian* of Andrarum; and Divisions 3, 2, and 1 to the *Paradoxidian* zones of *Agnostus lævigatus* (5), *P. Forchhammeri* (4), and *Par. Tessini* (2) of the same locality.

The same three divisions of *Paradoxidian* are recognizable also in Nerike,[6] where they are likewise underlain by the usual basal sandstone formation with *Scolithus*, etc. The *Olenidian* of Nerike has also the Westrogothian facies, the upper portions affording *Peltura scarabeoides*, and the lower *Parabolina spinulosa* and *Agnostus pisiformis*, etc.

The *Paradoxidian* zones *P. Tessini*, *P. Forchhammeri*, and *Agnostus lævigatus* are found locally in Jemtland, and Ostrogothia.[7]

In the Island of Öland the Cambrian Rocks have been carefully worked out by Sjögren,[8] and their fossils studied by himself and Linnarsson.[9] Three zones are recognizable in the Paradoxidian of

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[1] Nathorst, Kambriska och Siluriska lagren vid Kiviks Esperöd, Geol. För. Förhandl. 1876.

[2] Tullberg, *Agnostidæ* of Andrarum, table 3, p. 10.

[3] Linnarsson, Vestergötlands Cambriska och Siluriska Aflagringar, Stockholm, 1869.

[4] Linn. Nagra försteningar Vestr. sandstenlager O.K.V.A.F. 1869.

[5] Linnarsson, *op. cit.* p. 41.

[6] Linnarsson, Öfvers Nerikes Öfvergangsbildningar, O.K.V.F., Stockholm, 1875.

[7] Linnarsson, *Brachiopoda Paradoxides* Beds, p. 6.

[8] Sjögr., Anteckningar om Öland, Ofv. K.V.A.F., 1851; Bidrag Öland's Geologi, ibid. 1871; Nagra försteningar Ölands Kambriska lager, Geol. För. Förhl. 1872, etc.

[9] Linnarsson, Geol. För. Förhl. Bd. II. p 79; Geologiska iakttagelser på Oland, ibid, 1875; Brachiopoda Paradoxides Beds, 1876.

the island. Lowest of all occur (1) arenaceous flagstones with *Paradoxides Tessini*, *Liostracus aculeatus*, Ang., *Ellipsocephalus muticus*, Ang. Next is supposed to occur a peculiar zone, as yet recognized in no other region—(2) the Zone of *Paradoxides Ölandicus*, Sjög., consisting of greenish shales and interstratified calcareous beds with few fossils. Lastly, we have (3) the widely-distributed Zone of *P. Forchhammeri*, or "Andrarum Limestone," with all its characteristic species.[1] There is here no visible trace of the terminal or *Agnostus lævigatus* zone; but the Andrarum Limestone is at once surmounted by the basal zone of the Olenus-bearing beds. In the lowest strata (1) of the *Olenidian* occur the usual forms of *Agnostus pisiformis*, Linn. Next come (2) strata with *Beyrichia Angelini* and *Olenus gibbosus*. Above these follow (3) the beds with *Orthis lenticularis* (representing the zone of *Parabolina spinulosa?*), leading up into (4) shales with *Leptoplastus* and *Eurycare latum*, and the Olenidian section is terminated by the ubiquitous zone of (6) *Peltura scarabeoides* and *Sphærophthalmus*.

Cambrian Rocks of Norway.

Our chief authority for the physical and palæontological succession among the Cambrian deposits of Norway is the veteran geologist Professor Kjerulf, of Christiania, who has recently added to his many accurate and well-known memoirs[2] on the rock-formations of Southern Norway, a voluminous and elaborate work on the Geology of Southern and Middle Norway,[3] in which the manifold results of the labours of himself and his colleagues are ably summarized for the general student. Excluding from our present consideration those areas where it is supposed by the Norwegian geologists that the Lower Palæozoic Rocks have been more or less metamorphosed, we find everywhere in Norway the same general arrangement of sediments and fossil forms we have already recognized in Sweden. A formation of quartzose sandstone of variable thickness rests unconformably upon the gneissose rocks, and supports a thin group of Alum Schists (rarely more than 100 feet in thickness) with *Paradoxides* and *Olenus*. The sandstones are usually much thinner than in Sweden, and the Paradoxidian is occasionally more or less arenaceous in character, and is developed only in certain localities.

At the railway station of Krekling, near Kongsberg, the lower beds have been studied in detail by Brögger, who was the first to detect the existence of the Paradoxidian in Norway. Here[4] they consist of the following members:—

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[1] Linnarsson, Iakttagelser på Oland, p. 6, etc.

[2] Kjerulf, Das Christiania Silur-Becken, 1855; (and Tellef Dahl), Geologie des Südlichen Norwegens, 1857; Veiviser, 1865; (and Hanan), Om Trondhjems Stifts Geologi, 1875, etc.

[3] Udsigt over det sydlige Norges Geologi (1879). German translation, by Dr. Gurlt (Die Geologie des Südlichen und Mittleren Norwegen), Bonn, 1880.

[4] W. Brögger, Paradoxides-skiferne ved Krekling, Nyt. Mag. f. Naturvidernskaberne, 1876, etc. Trondhjemke Fossiler, ibid. 1875; also Geol. Foren. Forhand. 1875, 1876.

COMPARATIVE TABLE OF THE CAMBRIAN ROCKS OF BRITAIN AND SCANDINAVIA.

	BRITAIN.	SWEDEN.	NORWAY.
BRIAN, Sedgwick. Murchison, Barrande, etc. *Olenidian*	MIDDLE CAMBRIAN of Sedgwick, UPPER CAMBRIAN of Hicks. (LINGULA FLAGS or *Primordial Silurian* of Murchison, in part.) IV. LOWER TREMADOC of Salter and Belt. (*a*) TREMADOC BEDS, with *Asaphellus Homfrayi*, Salt. *Conocoryphe depressa*, Salt., etc. (Tremadoc, ? Shineton, etc.) (*a*) DICTYONEMA BEDS, with *Dictyonema socialis*, Salt. (Tremadoc, Malvern, Shineton.)	IV. UPPER ALUM SCHISTS (*Regio Olenorum* of Angelin), *Primordial Zone*, *Phases posterieures aux Paradoxides* of Barrande. *B* DICTYONEMA SCHISTS of Linnarsson, etc. (2) Strata with *Obolella Salteri*, Holl. (1) Strata with *Dictyonema flabelliforme*, Eich. (Scania, Ostrogothia, etc.)	ALUM SCHIEFER OLENUS ETAGE of Kjerulf, with *Dictyonema*, *Norvegicum*, etc. (*Christiania*)
	III. DOLGELLY GROUP of Belt. (2) UPPER DOLGELLY (Moel Grün Slates), with *Conocoryphe invita*, Salt., *Agnostus trisectus*, *Peltura scarabeoides*, Wahl., *Ctenopyge pecten*, Salt., *Sphærophthalmus alatus*, Beck, etc. (North Wales, Malvern Hills.) (1) LOWER DOLGELLY (Rhiwfely Slates), with *Parabolina spinulosa*, Wahl., *Orthis lenticularis*, Wahl., *Agnostus* and *Protospongia*. (North Wales, Malvern.)	(*A*) OLENUS SCHISTS of Linnarsson, etc. (7) Strata with *Cyclognathus micropygus*, Lins. (6) Strata with *Peltura scarabeoides*, Wahl., *Agnostus trisectus*, *Ctenopyge pecten*, *Sphærophthalmus alatus*, etc. Scania, Ostrogothia, Öland, Nerike, etc. (5) Strata with *Leptoplastus stenotus*, Ang. (4) Strata with *Parabolina spinulosa*, *Orthis lenticularis*, etc. (Scania, Ostrogothia, Öland, etc.)	*Peltura scarabeoides*, *Sphærophthalmus alatus*, *Parabolina spinulosa*, *Orthis lenticularis*,
	II. FESTINIOG GROUP of Belt. (2) UPPER FESTINIOG, with *Hymenocaris vermicauda*, Salt., *Conocoryphe macrura*, Salt., etc. (1) LOWER FESTINIOG with *Lingulella Davisii*, M'Coy, *Buthotrepis*, etc.	(3) Strata with *Beyrichia Angelini*, Barr., *Agnostus cyclopyge*, Tullberg, etc.	*Lingulella Davisii*, M'Coy,
	I. MAENTWROG GROUP of Belt. (2) UPPER MAENTWROG, with *Agnostus pisiformis*, Linn., *Agn. reticulatus*, Ang., *Olenus cataractes*, Salt. (1) LOWER MAENTWROG, with *Agnostus pisiformis*, Linn., *Olenus gibbosus*, Wahl., *Olenus truncatus*, Salt. (North Wales.)	(2) Strata with *Olenus truncatus*, Brn., *Agnostus pisiformis*, Linn., *Agnostus reticulatus*, Ang., etc. (1) Strata with *Olenus gibbosus*, Wahl., *Agnostus pisiformis*, Linn., etc.	*Agnostus pisiformis*, Linn. *Olenus gibbosus*, Wahl. (Christiania, etc.)

Middle Cam- Primordial Silurian, *Paradoxidian*	LOWER CAMBRIAN of Hicks. (ii) MENEVIAN GROUP of Hicks. (iii) UPPER MENEVIAN (sandstones and shales), with *Orthis Hicksii*, Salt., *Obolella sagittalis*, Salt., etc.	III. LOWER ALUM SCHISTS (*Paradoxides Beds*) of Linn. (6) Strata with *Agnostus lævigatus*, Dalm., *Kutorgina cingulata*, etc. (5) Strata with *Paradoxides Forchhammeri* (Andrarum Limestone), *Orthis Hicksii*, *Obolella sagittalis*, Salt., *Agnostus glandiformis*, *Agn. aculeatus*.	PARADOXIDES ETAGE of Kjerulf (*d*) Upper Niveau with *Paradoxides Forchhammeri*, Ang. *A. glandiformis*, *A. aculeatus* (Krek.)
	(ii.) MIDDLE MENEVIAN (black flag), with *Paradoxides Davidis*, Salt., *Agnostus Barrandei*, Salt.	(4) Strata with *Paradoxides ölandicus*, Sjg., *Agnostus regnus*, etc. (3) Strata with *Paradoxides Davidis*, *Agnostus punctosus*.	(*c*) Middle Niveau with :— *Paradoxides Davidis*, Salt., *Paradoxides Tessini*, Br., *Agnostus fallax*, Linrs. (Krekling).
	(i) LOWER MENEVIAN (grey flags), with *Paradoxides Hicksii*, Salt., *Obolella sagittalis*, Salt., *Agnostus Davidis*, Salt., *Conocorphye coronata*, Barr. (St. Davids and N. Wales.)	(2) Strata with *Paradoxides Tessini*, Brongn. (*c*) Subzone with *Agnostus rex* (Barr.) (*b*) Subzone with *Paradoxides Hicksii*, Salt. (*a*) Subzone with *Paradoxides palpebrosus* (Exsulans Limestones), *Conocoryphe exsulans*, Linrs., *Agnostus fallax*, Linrs., *Obolella sagittalis*, Salt.	
Lower Cambrian, Sedgwick, Cambrian, Murchison, Barrande,	I. HARLECH (LONGMYND) ROCKS of Hicks. (ii) SOLVA GROUP (Hicks, MS.) (3) U. SOLVA (grey flags), with *Obolella sagittalis*, Salt., *Paradoxides aurora*, Salt., *Conocoryphe bufo*, Salt., etc. (2) MIDDLE SOLVA (coloured rocks), with *Paradoxides Solvensis*, Hicks, MS., *Agnostus Cambrensis*, Hicks, *Eophyton*, sp. etc. (1) LOWER SOLVA (yellowish flags and grits), with *Paradoxides Harknessi*, Hicks, *Plutonia Sedgwickii*, Hicks, *Eophyton*. (St. Davids.)	(1) Strata with *Paradoxides Kjerulfi*, Linrs., *Lingulella Nathorsti*, etc. (Andrarum, Bornholm, Öland).	Lower *Paradoxides* Niveau with *Paradoxides Kjerulfi*, *Arionellus*, etc. (Tomten, etc.)
Annelidian	(i) CAERFAI GROUP of Hicks (MS.). (3) UPPER CAERFAI (massive purple sandstones), with Annelides only.	II. FUCOID SANDSTONE of Linnarsson, etc., with *Lingulella* (*Obolella*) *favosa*, Linrs., etc.	Quartz Sandstone of Kjerulf.
	(2) MIDDLE CAERFAI (red shales), with *Lingulella Cambrensis*, Hicks, (*Discina Caerfaiensis* Hicks, MS.), *Leperdites Cambrensis*, Hicks, etc. (1) LOWER CAERFAI (green flaggy sandstones and occasional conglomerates), with Annelides only. (St. Davids.)	I. EOPHYTON SANDSTONE of Linnarsson, etc., with *Eophyton Linneanum*, *Cruziana dispar*, *Astylospongia*, *Obolus?*	

(3.) Dark clay slate with *Paradoxides Forchhammeri* ... ... 22 feet. containing among other forms, *Agnostus Kjerulfi*, *A. brevifrons*, Ang., *A. aculeatus*, Ang., *A. glandiformis*, Ang., *A. lævigatus*, Dalm., and species of *Protospongia*.

(2.) Black clay slate with *Paradoxides Tessini* ... ... 60 feet. together with *Paradox. rugulosus*, Brög. (an associate of *P. Davidis* at Bornholm), *Agnostus fallax*, Linrs., *A. parvifrons*, Linrs., *A. gibbus*, Linrs., *A. incertus*, Brögg., forms all characteristic of the same beds in Sweden.

(1.) Greywacke Schists, sandstone, and conglomerate ... ... 8 feet.[1]

In the well-known Lower Palæozoic series of Christiania, the Paradoxidian proper is so poorly developed that it has not yet been definitely recognized; and the Alum Schists of the neighbourhood of that city, which are about 100 feet in thickness, appear to belong almost entirely to the *Olenidian*. It may be regarded as certain that all the Swedish palæontological zones will ultimately be recognized within them, as they are known to contain the characteristic species:—

d. Dictyonema flabelliforme.[2]
c. Peltura scarabeoides, *Orthis lenticularis*.
b. Parabolina spinulosa, *Sphærophthalmus alatus*.
a. Olenus gibbosus, *Agnostis pisiformis*, *Lingulella Davisii*, etc.

On Lake Miösen,[3] red and white quartzose sandstone is overlain by (*a*) green clay slate with *Paradoxides Kjerulfi*, Linrs., *Arionellus*, (*b*) Alum Schist with *Agnostus parvifrons*, and (*c*) Alum Schist with *Agnostus pisiformis*. To the northward of this locality the Cambrian zones are confusedly intermingled with metamorphic rocks, and have themselves been so pierced and hardened by igneous intrusions that they are no longer individually recognizable; and with the disappearance of their fossils they lose their interest for the comparative geologist.

In the preceding table (pp. 320–321) the accepted divisions and subdivisions of the Cambrian strata of Britain and Scandinavia are arranged in parallel columns, the local zones which seem to be of the same general geological date being placed in corresponding positions. The more important data brought forward in the foregoing pages are inserted, together with much that is already familiar to British geologists. The detailed classification of the various fossiliferous zones recognizable in the Harlech Rocks of St. Davids has been copied from some unpublished notes kindly placed at my service by my friend Dr. H. Hicks, who has long since earned the right to be regarded as our chief authority upon the sequence and fossils of the British Cambrian deposits.

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[1] Kjerulf, Die Geologie des (sudlichen und) mittleren Norwegen (Gurlt), Bonn, 1880, p. 61.

[2] Kjerulf, *ibid.* pp. 68-69; Veiviser, Christiania, 1865, pp. 1, 2, etc.

[3] Kjerulf, Mittler Norwegen, p. 133.

NOTICES OF MEMOIRS.

I.—Tertiary Geology of the Reggiano (Calabria).[1]

IN a large quarto volume of the memoirs of the Accademia dei Lincei, Professor Sequenza gives a description of the geology of the province of Reggio in Calabria, and gives a classified list of all the fossils found in the Tertiaries, together with a description of new species, accompanied with numerous figures. The number of fossils reaches the astonishing figure of 2686, of which 994 are now known living, and 445 are considered new. The same author has already described and given lists of Sicilian fossils belonging to various classes, and while, as a rule, palæontological work is better where it is not spread over too wide a field, yet Prof. Sequenza stands very much alone in his Calabrian and Sicilian work, and therefore it is the more important to make the work as comprehensive as possible, and by the present communication he has erected a memorial of his industry, to be compared with the series of works on French palæontology published by D'Orbigny.

About one-half of the Reggiano consists of crystalline rock and most of the rest is Tertiary. After the "terrain primitive" and Palæozoic schists, Jurassic and Cenomanian beds are found in a few places; but when we come to the Cainozoic there is an almost uninterrupted series of all the Tertiary formations; the Eocene is, however, not so instructively developed as the Middle and Upper Tertiaries. The Parisian, Bartonian, and Ligurian, are found with but few fossils, and those mostly Protozoa; but as much attention has not been given to these as the Miocene and Pliocene beds, and Professor Sequenza thinks that with further study more may possibly be learnt about them.

The really fossiliferous beds begin with the Tongrian, in which nearly all classes are present; but the Aquitanian, Langhian, Helvetian, and Tortonian, are all much richer in fossils, both the Helvetian and Tortonian being extremely interesting, not only from the large number of fossils found, but also from the general character of the fauna, most classes being well represented. In the Helvetian 329 species are mentioned, 69 of which are living, and 893 species were found in the Tortonian, 23 per cent. of which are living. The term oligocän is here dropped, as it is thought best to unite beds of that age to the Miocene. The Messinian was unfossiliferous, and the author of the memoir considers that there has been a misunderstanding about the Messinian, a name, he points out, first given by Carl Mayer for a zone at the close of the Miocene, which he erroneously placed as coetaneous with the Zanclean of South Italy, a formation deposited in a somewhat deep sea and now known to be of later age than the Messinian and certainly Pliocene. The Messinian is known through Italy and Sicily as the Congeria or Gypsum-sulphur beds. The Miocene covers a diminishing area

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[1] Le Formazioni Terziarie nella Prov. di Reggio (Calabria), del Prof. G. Sequenza, Mem. Accad. dei Lincei, vol. cclxxvii., 1880. With Maps and Plates.

from the Langhian upwards, and the way the last formations are only found in patches show what great denudation has taken place.

The Pliocene is found at a much greater elevation than any of the other Tertiary series, reaching in the Zanclean to 1200 mètres above the sea, and as the conditions of deposition were quite different here from those which obtained in north Italy, the series in one part of the peninsula forms a complement to those in the other. It commences with the Zanclean, and this at the base is formed of a conglomerate; then follow fossiliferous beds with 650 species of various classes, among which 52 Radiolaria and 165 Bryozoa. A considerable amount of denudation also took place before the Astian, a formation which was frequently deposited in the depression caused by this denudation, and many mistakes have thus arisen, as the Astian found lower down has been taken for Zanclean, and thought to underlie it. The number of fossils in the Zanclean mounts up to 1175, of which 463 are Gasteropoda, 77 Bryozoa, and 190 Rhizopoda, and of the whole number 652 are now known living; but Professor Sequenza points out how such comparative lists are liable to variation, for in 1870 he published a note on the Astian fossil mollusca of southern Italy, found in the north Atlantic, and not in the Mediterranean, but since then seven of these have been discovered in the Mediterranean; he, however, now mentions 23 more species from the Calabrese known living, but not in the Mediterranean. The Sicilian is also found at a very considerable height above the sea, and the Saharian at an elevation of 832 mètres. Of the 702 species of fossils from this latter formation a few are tropical, but careful examination has reduced the number of cases which were at first thought to be identical with forms from warmer climates, and some occur in the recent Quaternary which had been found in the Tortonian, and then were not found in the Pliocene or Lower Quaternary, and it is considered that they emigrated to the south when the temperature became colder, and subsequently returned upon it becoming warmer; on the other hand, in the Astian, Sicilian, and Lower Quaternary, a number of northern species had been found indicating a colder climate. All the Saharian was a period of elevation, and as this took place the Mediterranean Sea became smaller, and thus the communication with the warmer seas became more restricted.

In most of the formations a conglomerate is found, but the latter ones seem to be derived from older ones, as shown by the lithological similarity, and in all a dioritic porphyry occurs, only found, *in situ*, by Catanzaro.

The changes of level are carefully followed, beginning with the Parisian, which was formed at a considerable depth, followed by elevation in the Bartonian, reversal again taking place at the commencement of the Ligurian, while at the close of the period there was elevation, which continued into the Tongrian, towards the close of which depression again commenced, and continued into the Aquitanian, and until the end of the Langhian the conditions were deep, when an elevation and formation of conglomerate took place, to be followed by a small depression in the beginning of the

Messinian, but through the rest of the Messinian an elevation continued. The greatest depression of all took place in the Zanclean, which was deposited in great depths, as shown by the fauna, by having such a large extension, and by occurring up to such a great height as 1200 mètres above the sea; through the Astian this depression continued, but at the Pliocene the elevation took place which gave to the province its present configuration.

Professor Sequenza considers that as yet only the Mollusca have been sufficiently studied to permit of a satisfactory comparative list of fossils and living Mediterranean species being drawn up, and even with this class he points out fresh discoveries are being made. In one group, the Bryozoa, we know of several additions as yet unpublished to be made to the Mediterranean fauna, which will considerably alter the proportion of living to extinct.

The various zones of the Miocene are found to be well characterized by the *Clypeasteridæ*, of which different characteristic species are found in the Tortonian, Helvetian, Aquitanian, and Tongrian, almost each form being limited to a single geological zone.

A. W. W.

II.—Jurassic Corals of North Italy.[1]

PROF. D'ACHIARDI, in this important memoir, divides the subject into three parts; the first treats of the Corals of Monte Pastello, in the province of Verona. The *Madreporaria* aporosa of this district consist of one or perhaps two species of *Montlivaultia* (the doubtful species *M. ? caruli*, being new). Of the *Stylosmilinæ*, *Placophyllia elegans* is described as new. The *Polyastreæ* consist of a new species of *Diplocœnia* (*D profunda*), one of *Stylina* (*S. taramellii*, a *Stephanocœnia*, five *Isastrœæ*, one *I. Montispastelli*, being new to science), four *Latimæandrinæ*, of which three are new and peculiar to this formation, but related most nearly either to Miocene or Middle and Lower Secondary forms, and a new species (*amplistellata*) of *Comoseris*, a genus which similarly ranges from the Great Oolite to the Miocene. The stratigraphical position of the beds from which these corals were obtained, as determined from their fossil contents, is placed between the Great Oolite and the Coral Rag, but the exact place is rather uncertain.

From various other localities near Verona are described a *Montlivaultia*, a *Stylina*, a *Thamnastrœa*, and three new species referred, with doubt, to the genera *Latimœandrina*, *Oroseris*, and *Beaumontia* respectively; the correctness or not of the identification of the last-named species is important, as the genus *Beaumontia* is mainly Palæozoic in range, and hitherto represented by one species—viz. from the Australian Tertiaries—in any later rocks.

The beds in this locality appear to belong to the Dogger group.

The neighbourhood of Mentone furnishes fourteen species of corals from a coarse, friable, calcareous rock.

Besides single unnamed species of *Montlivaultia*, *Rhabdophyllia*,

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[1] Atti Soc. Toscana Sci. Nat. (Pisa) Mem. iv. (1880), pp. 233-310, 4 pls.

and *Stylina*, a species is referred to *Calamophyllia Stokesi*, already known from the Coral Rag, and one, with doubt, to *C. radiata* of the Great Oolite, and two species, described originally under the genera *Astrocœnia* and *Holocœnia* respectively, are referred to *Stylina.* The remaining eight species are new to science, and consist of *Calamophyllia Mentonensis*, most nearly related to two Coral Rag species, *Thecosmilia spadæ*, with allies in the Coral Rag and Inferior Oolite, *Cladophyllia Mentonensis, Pachygyra costata*, and *Stylina nicoensis*, an octomeral species, which is intermediate between *S. pistillum* and *S. octonaria.* A new genus is found in the family Astræniæ, named *Diplocœniastræa*, for a new species called *D. Italica*, it differs from *Diplocœnia* by the toothed character of the septa and the spongy texture of the columella. Among the Cladocorallæ a new species is described as *Pleurocora* ? *Roccabrunæ*, a new Tabulate is named *Cryptocœnia incerta.* The rock evidently belongs to the Coralline Oolite, and is consequently more recent than that of Monte Pastello.

From the sandstone of Monte Cavallo, of the Friuli district, twenty species were obtained, of these fifteen were *Madreporaria* aporosa, four were Tabulata, the remaining one was the Upper Coralline Oolite species *Microselena tuberosa.* Eight out of the fifteen species were hitherto undescribed, and are named *Calamophyllia substokesi, Septastræa colturensis, Phyllastræa forojulensis*, and *P. dubia, Stylina irradians, S. stipata, S. arborea, Isastræa Italica.* The Tabulates were all new and are named *Cryptocænia subbrevis, C. colturensis, C. ? incerta, Cyathophora Pirovæ.* The affinities of the species are chiefly with those of the Coralline Oolite. In the calcareous rock immediately underlying the sandstone were found ten species, including the above new species *Phyllastræa forojulensis*, the new species *Stylina digitiformis*, and two species possibly identical with two forms described from the before-named bed,—in all nine Aporosa, and one species of Porosa. The Coral fauna of this group of rocks, as well as their Mollusca, have already been determined to be Upper Coralline Oolite.

Note.—It should be observed that the names of a few of the new species were given by Prof. Meneghini, but as he appears not to have published any description of them, the author's name in their case also should stand as "D'Achiardi."

REPORTS AND PROCEEDINGS.

INTERNATIONAL GEOLOGICAL COMMISSION.

AT meetings held by the Committee of Organization for Great Britain and Ireland (Prof. T. Mc K. Hughes, M.A., President), the following definitions have been agreed upon.

SYSTEM.—The word *System* shall be applied to a group which stands by itself, easily and clearly distinguishable from the rocks above and the rocks below, and is generally bounded above and below by a well-marked break in stratigraphical sequence, and is characterized by special forms of life.

Formation.—The term *Formation* shall be applied to a smaller group of rocks which have some lithological or palæontological character in common, but which may be in continuous sequence with the rocks above and those below.

Deposit.—*Deposit* was defined as a term applicable to a smaller division than *Formation,* and generally implying similarity of lithological character.

Zone, Horizon.—*Zone* was defined to be part of a *Formation* characterized by one or more well-marked species, and *Horizon* was allowed to be correctly used for such part of a *Formation,* when it is recognized elsewhere by other characters, though the fossils may be absent.

It was agreed that *Bed, Group, Series,* should be left undefined. Some other terms still remain under discussion.

Concerning Time-words, it was agreed that *Period* should be used for the largest division, and should signify a completed and well-defined portion of time. *Age* was defined as a term used to indicate the portion of time marked by the prevalence of certain forms of life or of similar material having a distinct and well-marked character. *Epoch* was defined to mean a point of time, an interval short in comparison with the *Periods* and *Ages* of which it forms a part. It was considered that it could hardly be applied to the whole duration of even any one form of life, though it might to the transitory appearance of a species for a short time in one area. *Cycle* and *Date* were left undefined, and the definition of *Era* was postponed.

Geological Society of London.

I.—May 11, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Notes on the Fish-remains of the Bone-bed at Aust, near Bristol, with the Description of some new Genera and Species." By James W. Davis, Esq., F.S.A., F.G.S.

The fossil fishes described in this paper are from the Rhætic bed at Aust Passage. The stratum containing the fish-remains is rarely more than nine inches thick, often considerably less, and is composed of rounded masses of hardened clay or marl, which, at the time of their deposition, were soft enough to receive the impressions of the coprolites and fish-remains. There are large numbers of coprolites and bones of fishes, as well as some remains of Saurians, mingled with each other indiscriminately. The fishes belong to the orders Plagiostomi and Ganoidei, some of the former being of considerable size. It is inferred, from the intermixture of Saurians and fishes, that the deposit is the result of shallow water existing near land, in which the fishes lived and the Saurians occasionally disported themselves.

Besides the fossil remains of the animals which lived during the deposition of the Aust-beds, there are also others which appear to have been derived from the Mountain Limestone and the Coal-measures, representing such genera as *Psammodus, Psephodus, Helodus,* and *Ctenoptychius.* Fossil teeth of these genera occur scattered rather sparingly through the mass; they are very perfectly preserved, and do not show any signs of attrition. They must, however, be the result of the disintegration of older rocks, or the genera which they represent existed to a much later period than is generally supposed. The following new species were described:—*Ctenoptychius Ordii, Nemacanthus filifer*, Ag., varieties *α* and *β*, *Nemacanthus minor, Sphenonchus obtusus, Hybodus Austinensis* and *pustulosus, Petalodus?*

2. "On some Fish-spines from the Coal-measures." By J. W. Davis, Esq., F.S.A., F.G.S.

The author described in this paper three species of a new genus of fossil fish from the Carboniferous formation, two of the species having been found in the Cannel Coal of the West Riding of Yorkshire, and the other in the Burghlea limestone, near Edinburgh. *Anodontacanthus* is a straight spine, offering many points of resemblance to some of the Pleuracanths; it has a similarly close-grained microscopical structure, the internal cavity opens terminally at the base of the spine, and it was not deeply implanted in the flesh of the fish. It, however, differs from all the Pleuracanths in being quite free from external denticles; its surface is plain or but slightly striated, whilst that of *Pleuracanthus* always possesses a double row of denticles, either ranged laterally along the exposed part of the spine, or in some position between the lateral and posterior aspects of the spine. It is possible that evidence may be discovered which will render necessary the removal of these spines to the genus *Pleuracanthus;* but at present there is no evidence that such is advisable. All the specimens of *Pleuracanthus*-spine found associated with teeth or shagreen have been armed with the double row of denticles, and at present no evidence exists that spines without denticles were associated with remains of this genus. It is, therefore, considered best to institute a new genus for the three species with the name *Anodontacanthus*, in allusion to its having no teeth or denticles.

3. "On some Specimens of *Diastopora* and *Stomatopora* from the Wenlock Limestone." By Francis D. Longe, Esq., F.G.S.

Mr. Longe showed and described some specimens of Bryozoa from the Wenlock Limestone of Dudley, which he compared with corresponding forms from the Oolites and later periods, and pointed out the close similarity of the Silurian with the later forms, in respect of the shape and dimensions of the cells, as well as in the habit of cœnœcic growth.

Alluding to some other Palæozoic forms, assigned to the Bryozoa under the generic names of *Berenicea* and *Ceramopora*, he pointed out the difference between the shape of the cells in these forms and those which he had described, and expressed a doubt whether they should be classed as Bryozoa at all.

On the other hand, he referred to some specimens described by Professor Nicholson (Ann. & Mag. Nat. Hist. vol. xv., 1875) under the names of *Alecto auloporoides*, etc., as having the true Bryozoan cell, and furnishing additional evidence of the existence in the

Silurian seas of forms of Bryozoa which, though very abundant in the Oolites and all subsequent periods, were not generally supposed to have existed in the Palæozoic period.

4. "On a New Species of *Plesiosaurus* (*P. Conybeari*) from the Lower Lias of Charmouth, with Observations on *P. megacephalus*, Stutchbury and *P. brachycephalus*, Owen." By Prof. W. J. Sollas, M.A., F.R.S.E., F.G.S., etc., Professor of Geology in University College, Bristol; accompanied by a Supplement on the Geological Distribution of the Genus *Plesiosaurus*, by G. F. Whidborne, Esq., M.A., F.G.S.

The greater part of this paper was devoted to the description of a remarkably fine specimen of *Plesiosaurus* from the *Ammonites-obtusus* zone of the Lower Lias, Charmouth. Its distinctive characters are as follows:—

1. The length of the skull is 19·75 in., taken from the anterior extremity of the lower jaw to the posterior margin of the quadrate.
2. There are sixty-six vertebræ, of which thirty-eight are cervical, twenty-one dorsal, two sacral, and five caudal.
3. The length of the neck is 83 in., and the cervico-cephalic index 24·1 in.
4. The length of the cervico-dorsal series is 136 inches, and the cervico-dorsal-cephalic index is 14·6.
5. The length of the centrum in the anterior cervical vertebræ is equal to the height, and greater than the breadth of the articular face. In vertebra xv. the measurements are—length 2 in., breadth 1·5 inch, height 2 inches.
6. In the posterior cervical vertebræ the breadth of the articular face is greater than the length or height, but the latter two dimensions remain equal.
7. The neural spines increase in size up to vertebra xl., in which they measure 4·75 inches in length.
8. The neural spines are inclined backwards as far as vertebra lv.; past this, up to lvii., they are inclined forwards; but afterwards they again incline backwards.
9. The humerus and femur are nearly equal in length, the femur being slightly the shorter.

For the species the name of *P. Conybeari* is proposed. *P. Conybeari* agrees closely with *P. Etheridgii* in the relative length of head and neck; but it has eight more cervical vertebræ than the last-mentioned species. In the number of the cervical vertebræ it agrees with *P. homalospondylus*, but has a much larger cervico-cephalic index.

5. "On certain Quartzite and Sandstone Fossiliferous Pebbles in the Drift in Warwickshire, and their probable identity with the true Lower Silurian Pebbles, with similar fossils, in the Trias at Budleigh Salterton, Devonshire." By the Rev. P. B. Brodie, M.A., F.G.S.

The author notices some previous remarks upon these pebbles, which, in Warwickshire and elsewhere, either occur in the Trias or have been derived from it. To account for these, he supposed that there had been a more northerly extension of Silurian rocks than can now be detected in Central England. The Lickey quartzite has been supposed to have contributed some of these; but the author states that he has not found any one well-defined Llandovery species, but that the most characteristic are Lower Silurian. These pebbles are most abundant south of Birmingham, towards Warwick and Stratford-on-Avon. They agree lithologically with the Budleigh Salterton pebbles; these, as it has been shown, are partly Lower Silurian, partly Devonian, partly Carboniferous. The author gives a list of species collected by him from the Warwickshire pebbles. Sixteen are present from the twenty-four Lower Silurian forms found in Devonshire. Notwithstanding their identity, physical considerations forbid the supposition that they have been derived directly from that locality or Normandy, so that it is probable these Lower Silurian quartzite rocks once extended much further to the north.

II.—May 25, 1881.—R. Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Discovery of some Remains of Plants at the Base of the Denbighshire Grits, near Corwen, North Wales." By Henry Hicks, M.D., F.G.S. With an Appendix by R. Etheridge, Esq., F.R.S., Pres. Geol. Soc.

Traces of these fossils were first observed in 1875 by the author in Pen-y-glog quarry, about two miles E. of Corwen. Further research has resulted in the discovery of more satisfactory specimens, which have been examined by Messrs. Carruthers, Etheridge, and E. T. Newton. Among them are spherical bodies resembling the *Pachytheca* of Sir J. D. Hooker, from the bone-bed of the Ludlow series, supposed to be Lycopodiaceous spore-cases; also numerous minute bodies stated by Mr. Carruthers to be united in threes, and to agree with the forms of the microspores of Lycopodiaceæ, both recent and fossil; and some fragments, which may belong to these plants, and others, probably belonging to plants described by Dr. Dawson from the Devonian of Canada under the name of *Psilophyton.* The above testify to the existence of a very rich land-flora at the time. Mixed up with these, however, are numerous carbonaceous fragments of a plant, described also by Dr. Dawson from the Devonian of Canada, which he referred to the Coniferæ, but which is, according to Mr. Carruthers, an anomalous form of Alga. The former called it *Prototaxites;* the latter renamed it *Nematophycus.* Numerous microscopical sections, showing the beautiful structure of this interesting plant, from the specimens found at Pen-y-glog, have been examined by Mr. Etheridge and Mr. Newton, and their conclusions agree with those of Mr. Carruthers. The evidence seems to show that at this mid-Silurian period the immediate area where the plants are now discovered must have been under water, and that the mixture of marine and dry-land plants took place in consequence of floods on rapid marine denudation. The author indicated that the land-areas must have been to the south and west, chiefly islands, surrounded by a moderately deep sea, in which Graptolites occurred in abundance. The position of these beds may be stated to be about

2000 feet below the true Wenlock series, and about the horizon of the Upper Llandovery rocks.

2. "Notes on a Mammalian Jaw from the Purbeck Beds at Swanage, Dorset." By Edgar Willett, Esq., communicated by the President.

Excavations were undertaken last summer in this locality (Durlstone Bay, Swanage), where, rather more than twenty years since, the jaws of sixteen new species of Mesozoic mammalia were found by Mr. Beccles. These, though less successful than the former, resulted in the discovery of the larger part of the right mandibular ramus of a marsupial, about 1½ inch long. Six teeth are preserved *in situ*. This specimen was described and its affinities discussed by the author. He referred it to the genus *Triconodon*, described by Prof. Owen in his monograph (Palæont. Soc. 1871); the peculiarity of this specimen is that it has four teeth having the form of true molars, while those previously found have only three. *Triacanthodon*, indeed, has four true molars; but between it and the specimen described there are some important differences of detail. The dental peculiarity may be explicable on either of two hypotheses suggested to the author by Prof. Flower, and he thinks it better to refer it to *Triconodon mordax*, than to attribute it to a new species of the genus.

III.—June 8, 1881.—R. Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Reptile-fauna of the Gosau Formation, preserved in the Geological Museum of the University of Vienna." By Prof. H. G. Seeley, F.R.S., F.L.S., F.G.S.; with a Note on the Geological Horizon of the Fossils, by Edward Suess, F.M.G.S.

The collection of Reptiles described in this paper was obtained at Neue Welt, near Wiener Neustadt, by tunnelling into the freshwater deposits which there yield coal. A part of the collection was described by Dr. Bunzel in 1871; but the author's interpretation of the fossils rendered a re-examination of the whole collection necessary. All the species hitherto discovered are new, and, with the exception of those referred to *Crocodilus*, *Megalosaurus*, *Ornithochirus*, and *Emys*, are placed in new genera. Nearly all the bones are more or less imperfect.

The *Iguanodon Suessii*, of Bunzel, was referred to a new genus, *Mochlodon*, characterized by the straight anterior end of the ramus of the lower jaw, and by the vertical bar in the middle of the teeth of the lower jaw. There appear to be two teeth in the ramus. The tooth referred to the upper jaw has several uniform parallel vertical bars. A small parietal bone, referred by Bunzel to a Lizard, is considered by the author to belong probably to the same species, and, with some doubt, he associated with it the articular end of a small scapula.

Bunzel's *Struthiosaurus austriacus* was redescribed by the author, who indicated that the bones of the base of the brain-case, regarded by Bunzel as the quadrate bones, really belong to the occipital region, which necessitates a different interpretation. The foramina along the base of the skull were also described as presenting one of the characteristics of the Dinosaurian order. The base of the skull of *Acanthopholis horridus* was described to show its relation to the above type, with the view of demonstrating its Scelidosaurian affinities.

The greater part of the remains were referred by the author to a new genus, *Cratæomus*; some of these had been figured by Bunzel as "Crocodili ambigui," and others as belonging to *Scelidosaurus*, and to a new Lacertilian genus, *Danubiosaurus*. To *Cratæomus* he referred mandibles, teeth, vertebræ from all parts of the column except the sacrum, dermal armour, and the chief bones of the limbs. Two species were distinguished, *C. Paulowitschii* and *C. lepidophorus*. The former, which is much the larger, was named in honour of M. Paulowitsch, who voluntarily superintended the work at the Neue Welt. The author stated that he regarded these animals as carnivorous, and that, unlike the typical Wealden Dinosaurs, they were not Kangaroo-like in habit, but had strongly developed fore-limbs, as indicated in the proposed generic name.

Two teeth belonging to *Megalosaurus* were described as representing a new species, *M. pannoniensis*, characterized by the crown being shorter and broader than in previously described forms. A fragment, regarded by Bunzel as the thoracic rib of a Lizard, was interpreted as the distal end of the femur of a Dinosaur, and named *Ornithomerus gracilis*. The lower jaw, described by Bunzel as *Crocodilus carcharidens*, of which a maxillary bone also occurs, was made the basis of a new genus, *Doratodon*, probably Dinosaurian, judging from the lateral position of the apertures of the skull and the characters of the teeth. The genus *Rhadinosaurus* was founded upon the humerus and femur, the latter having been regarded by Bunzel as the dorsal rib of a Crocodile; the species was named *R. alcimus*. *Oligosaurus adelus* was described as presenting Lacertilian characters in combination with some Dinosaurian peculiarities. The remains include the humerus, femur and scapula, and two vertebræ, which were regarded by Bunzel as fœtal vertebræ of a Dinosaur. The genus *Hoplosaurus* was founded on some vertebræ, fragments of limb-bones, and dermal armour; it shows, with distinctive peculiarities, a certain resemblance to *Hylæosaurus*.

A procœlian Crocodile was represented by many parts of the skeleton; some figured by Bunzel as Lacertilian, others as Crocodilian. It is remarkable for having a buttress supporting the transverse process in the lumbar region. The author calls it *Crocodilus proavus*.

The specimen figured by Bunzel as the ilium of his *Danubiosaurus anceps*, was stated by the author to be a costal plate of a large Chelonian, in which, apparently, the margins of these plates remained separate through life. Skull bones, believed to belong to the same animal, are strongly sculptured; the author named the species *Pleuropeltus lissus*. Three or four species of Emydians were said to be indicated by isolated plates, the largest of which was named *Emys Neumayri*.

The only specimen referable with certainty to a Lizard is a small vertebra of elongated form, regarded as indicating a new genus and species, named *Spondylosaurus gracilis.* Of Pterodactyls there are but few remains; but these certainly represent two genera. The author only describes one species, to which he gives the name of *Ornithochirus Bunzeli.* There are, in all, probably ten genera of Dinosaurs and five genera of other groups, making fifteen in all.

The paper was supplemented by a note by Prof. Suess on the geological relations of the beds at Wiener Neustadt to those of the Gosau valley, in which he comes to the conclusion that they are older than the true Turonian deposits, and especially older than the zone of *Hippurites cornu vaccinum.*

2. "On the Basement-beds of the Cambrian in Anglesey." By Prof. T. McKenny Hughes, M.A., F.G.S.

In this paper the author first pointed out that there was in Anglesey:—(1) An upper slaty group, in which he had fixed two life zones, which showed that the series belonged to the Silurian (Sedgwick's classification), and (2) a lower group of slates and sandstones in which Arenig fossils had been found in several localities, and Tremadoc had been less clearly recognized, while by the correction of the determination of a species of *Orthis* there was now a suspicion of even Menevian forms. These all rested upon the Basement-beds of the Cambrian, of which the paper chiefly treated. They were made up of conglomerates, grits, and sandstones, with Annelids and Fucoids.

The Basement-beds varied in thickness and character, according to the drift of currents along the Pre-cambrian shore and the material of the underlying rocks. Near Penlon, where they rested on a quartz-felspar rock, they consisted chiefly of a quartz-grit and conglomerate, almost exactly like that of Twt Hill. Near Llanerchymedd, where there was a mass of greenish schistose rock succeeding the Dimetian, the Cambrian Basement-bed contained a large number of fragments of that rock, certain bands being chiefly composed of it. Near Bryngwallen, where the underlying Archæan consisted of gneissic rocks, the Cambrian Basement-beds were made up of quartz conglomerate. Tracing it still further to the S.W., he found bosses of conglomerate among the sand dunes of Cymmeran Bay, full of fragments of green schistose rock, like that of Bangor, and telling of the further development of Pebidian at the S.W. end of the Anglesey axis. In several localities these conglomerates were associated with and passed into fossiliferous grits and sandstones. He exhibited slices of the more important rocks, which he showed confirmed the results arrived at from other evidence. He pointed out that the observations now made confirmed the views he had expressed on a former occasion with regard to the Basement-beds of the Cambrian between Caernarvon and Bangor, where the deposits which rested upon the granitoid rocks of Twt Hill were either a kind of arkose or chiefly composed of quartz with a few pieces of mica-schist and jasper; but as he followed them a few miles to the N.E., he found that the quartz had got pounded into smaller grains, and the larger pebbles were chiefly of felsite, which here formed the shore, while further towards Bangor fragments of the still higher Bangor volcanic series helped to make up the Cambrian shingle-beach.

3. "Description and Correlation of the Bournemouth Beds.—Part II. Lower or Freshwater Series." By J. S. Gardner, Esq.

This was in continuation of a former paper by the author (Q.J.G.S. vol. xxxv. p. 209). The beds described are exposed east and west of Bournemouth and near Poole harbour, over a distance of about four miles. The author referred them to the Middle Bagshot, and stated that they are distinguished from the Lower Bagshot by the absence of the extensive pipe-clay deposits and the presence of brick-earths, and from the overlying beds by the absence of flints. They reach their extreme limit in the western area of the London basin, and are represented by the lignitic beds 19-24 of Prof. Prestwich's section. Lignites can be traced partly across the bay. The cliffs present an oblique section across a delta divisible roughly into four masses, one of which, from its confused bedding and want of fossils, is supposed to have been formed by the silting up of the main channel. The total thickness of the series was estimated at 600 to 700 feet. The inferences drawn by the author were as follows:—1. From the beds cut through showing a steep side to the west, that the river flowed from that direction; 2. From the absence of boulders or coarse sediment, that the area was flat; 3. From the absence of lignite, that there were catchment basins; 4. From the absence of flint and the quartzose nature of the beds, that no chalk escarpments were cut through, and that the deposits came from a granitic area; and 5. From the presence of wood bored by *Teredo*, that the beds belong to the lower part of the river in proximity to tidal water.

The flora was stated to be confined to local patches of clay. Those at the western end of the section are very rich, and distinguished from the rest by absence of palms and rarity of ferns. The beds near Bournemouth are still richer and very distinct; those east of Bournemouth are characterized by *Eucalypti*, Aroids, and *Araucariæ*; and those at the western end of the section by abundant Polypodiaceæ. It is remarkable that nearly every patch contains a flora almost peculiar to it; but the flora as a whole seems to pass upward to the Oligocene, but not down to the Lower Bagshot.

CORRESPONDENCE.

"KAMMPLATTEN" IN THE IRONSTONE OF BOROUGH LEE.

Sir,—I have now no doubt that the pectinated object from the Ironstone of Borough Lee, which I at one time supposed might possibly be a tooth, and in a recent Number of your Magazine (January, 1881) I described under the name of *Euctenius elegans*, belongs in reality to the same category as the "Kammplatten," which Prof. Anton Fritsch, of Prag, has recently described and figured as appertaining to the cloacal region of certain fossil Amphibia, *e.g.* *Ophiderpeton pectinatum* (Fritsch, Fauna der Gaskohle und der Kalksteine der Permformation Böhmens, Bd. 1, Heft 2, Tafel xx.). My attention has been directed to this fact by a newspaper report of a paper, recently read before the Geological Society of Glasgow, by Mr. John Young, in which he identified, as one of these "Kammplatten," an apparently allied relic from the Airdrie district, and which, judging from that report, must either be the same as Barkas's "*Ctenoptychius*" *unilateralis*, or closely related to it. The two specimens, from which I drew up my description of "*Euctenius*," have no elongated process or "handle," but in other respects there is an obvious general resemblance.

I may take this opportunity of mentioning that within the last few days I have obtained from the same ironstone a portion of a small Labyrinthodont mandible, set with teeth which have the same general configuration and markings as those of Messrs. Hancock and Atthey's *Batrachiderpeton*. R. H. Traquair.

THE HUTTON COLLECTION OF FOSSIL PLANTS.

Sir,—It has only within the last few days come to my knowledge (indeed only to-day authoritatively), that the Hutton Collection of Fossil Plants, at present deposited in the Museum of the Natural History Society of Northumberland and Durham at Newcastle, had been named by the Curator, Mr. Richard Howse, prior to the compiling by myself of a Catalogue of the Collection, published in 1878 by the North of England Institute of Mining and Mechanical Engineers. The labels on the specimens, referred to in the Catalogue, were therefore Mr. Howse's, and not, as I until now imagined, either William Hutton's original ones or mere copies of them.

Moreover, an unsigned MS. List of the specimens in the Collection, agreeing with the labels, with which I was furnished by the Mining Institute, and which was used freely by me in drawing up the Catalogue, must now be regarded as the result of much time and labour spent by Mr. Howse in identifying and naming the whole of the Hutton Collection.

I trust you will allow me space in your Magazine to hereby redress an injustice of which I was unaware at the time of its commission. G. A. Lebour.

College of Physical Science,
Newcastle-upon-Tyne, *May* 18, 1881.

SUBSIDENCE AND ELEVATION.

Sir,—Mr. Starkie Gardner, in his paper on the above subject, in the June Number of your Magazine, says (p. 245):—"The records of the Palæozoic rocks point to a comparative uniformity in the earth's surface in remote times, there being neither evidence of *great depths in the sea*, nor of mountainous elevations of the land."

The latest calculation of the average depth of the sea is a little over two miles. The area of land being, roughly speaking, about one-third of that of the oceans, it follows that if the solid part of the earth were a perfect spheroid, having neither depression nor elevation, it would be covered by an universal ocean nearly one and a half miles deep. Is there, therefore, any meaning in saying that there ever was a time when great depths of the sea did not exist?

The way some reasoners have of dealing with land and water reminds me of nothing so much as the instructions given to an Irish labourer, who asked his master how he was to dispose of a certain lump of rubbish. He was told "to dig a hole to put it in." "But," says he, "What am I to do with the stuff out of the hole?" The answer was *pat:* "Dig a hole big enough to hold both."

T. MELLARD READE.

REPLY BY THE REV. H. G. DAY TO THE REV. O. FISHER.

SIR,—Mr. Fisher cavils at my proof (GEOL. MAG. p. 237). I must apologize for the accidental interchange therein of the symbols α and β; a slip which affects neither its validity nor its relevance.

Mr. F. claims that I should correct his similar lapsus. Had this been my province, I should certainly have commenced by asking him to explain under what circumstances he finds it impossible to pass a vertical plane through the major axis of his ellipse (p. 21, line 2). Mathematicians had been accustomed to believe that any line could lie in a vertical plane.

H. G. DAY.

MISCELLANEOUS.

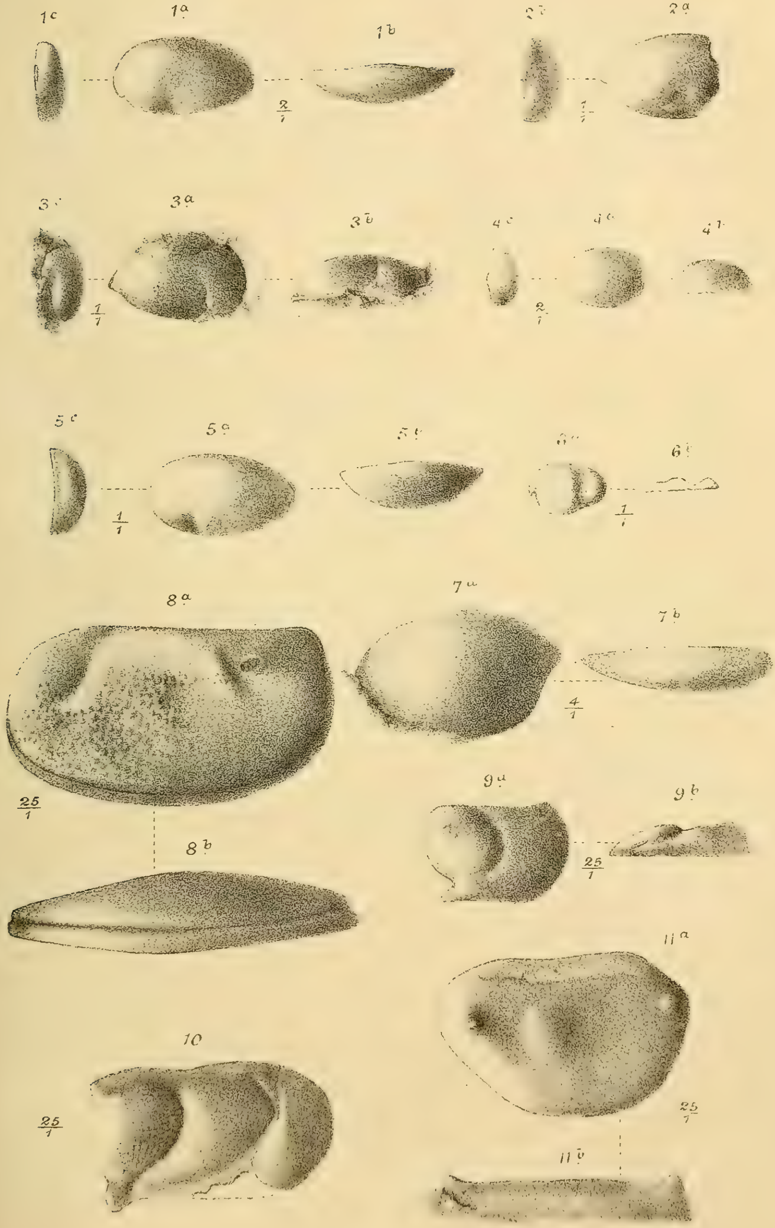
THE BLACKHEATH SUBSIDENCES.—Attention has been called in *Nature* (Feb. 17, 1881), and in *The Engineer* (Feb. 4, and March 18, 1881) to a series of subsidences that have taken place at Blackheath. In April, 1878, a subsidence of the ground occurred near a place called Rotten Row, the hole being 8 or 9 yards in circumference; in November, 1880, two holes appeared, one not far from the gravel-pit below Eliot Place and Heath House, and the other nearer to All Saints' Church.

The district is occupied by the Lower London Tertiaries—the Chalk occurring at about 100 feet from the surface; and several natural causes have been suggested to account for the production of these holes.

In seeking for an explanation, Mr. T. V. Holmes (*Engineer*, March 18) recalls attention to the discovery in 1878 of a pit, in all probability a Danes' Hole, at Eltham Park, within three miles of Blackheath, and mentions other ancient artificial excavations or "Danes' Holes" about Bexley, Chiselhurst, and in "Jack Cade's Cave" at Blackheath itself. He considers that the popular tradition that these Holes were originally intended as places of security for persons and property from Danish and other pirates and robbers, seems to be the most reasonable explanation of their existence.

Nevertheless, the question of their origin ought not to remain in abeyance, and it may be mentioned that a committee, comprising members of the Lewisham and Blackheath Scientific Association and of the West Kent Natural History Society, has been formed for the purpose of investigating the matter, and they invite contributions towards their object.

In connexion with this subject attention may be re-directed to a letter from Mr. H. Norton, F.G.S., on the Pits of the Haute Marne, see GEOLOGICAL MAGAZINE for June, 1877, Decade II. Vol. IV. p. 286.



G. M. Woodward lith. West Newman & Co imp

Palæozoic Ostracoda.

1.

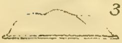
2.

3a.

4

5

3b.



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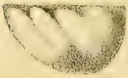

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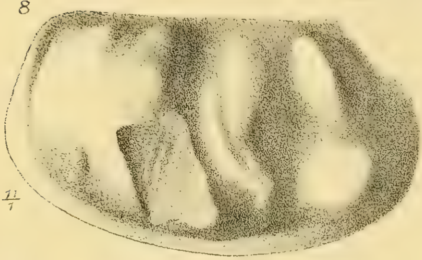

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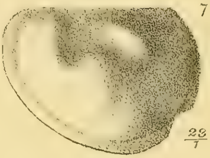

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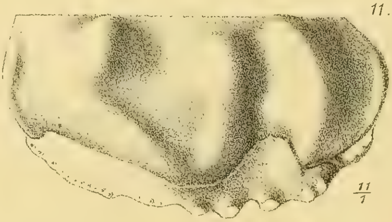
11.



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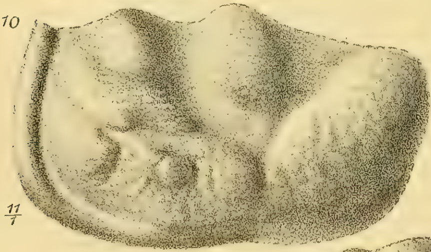

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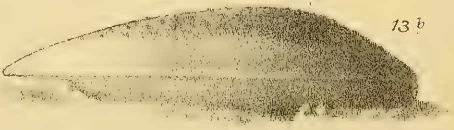
13a.

14a.

14b.

13b



G. M. Woodward lith.
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Palæozoic Ostracoda.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VIII.

No. VIII.—AUGUST, 1881.

ORIGINAL ARTICLES.

I.—Notes on some Palæozoic Bivalved Entomostraca.

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

(PLATES IX. and X.[1])

1. Cypridina? Plate IX. Figs. 7*a*, 7*b*.

Length, ¼ inch.

THE specimen here figured is an internal cast of a right valve, occurring in the well-known, reddish, fossiliferous, Palæozoic quartzite of the Triassic pebble-bed at Budleigh-Salterton, in Devonshire; and it resembles some forms of *Cypridina brevimentum*, J. and K. ("Monogr. Carbonif. Entom." Pal. Soc. 1874, p. 15, pl. 5, figs. 15–19), in general aspect; and also in some respects *Polycope simplex*, J. and K. (*op. cit.* p. 54, pl. 2, fig. 12). It was detected by the late Mr. J. W. Salter (in 1865?) during his enthusiastic study of that interesting conglomerate.

Mr. T. Davidson has brought together all that is known of this old pebble-bed of Devonshire, in his "Monograph of the Fossil Brachiopoda," Pal. Soc., Supplem. Part IV. 1881; and has therein and elsewhere added greatly to our knowledge of its palæontology, and of its geological relationships. Both Silurian and Devonian fossils are known to occur in the pebbles referred to; and, as far as appearances serve, the unique specimen under consideration is a *Carboniferous* form. We cannot say, however, that it may not have been *Devonian*, or even *Silurian*; for Bivalved Entomostraca of existing genera are represented by valves similar to their own (and valves are our only evidences) in various Palæozoic strata. The matrix is decidedly that of the other old pebbles of the conglomerate; and it would have been very strange if all and each of the three great formations should have given a *similar* quartzite to *one* pebble-bed.

Being only an internal cast in granular quartzite, with a portion of the margin (postero-ventral) still imbedded in the matrix, it fails to show any very distinct features, beyond an oval outline, with a broad, shallow, oblique, anterior antennal notch (scarcely making a beak), and with a moderate convexity of the valve, greater in front than behind.

If the want of prominence in the beak, owing to the *obsolete* condition of the notch or sinus, separates this form from *Cypridina*, and yet, if the prominence remains too strong for *Polycope*, we shall have

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[1] These two Plates have been drawn with aid of a Grant from the Royal Society for the illustration of the fossil Bivalved Entomostraca.

to remove both this and some Carboniferous forms, which have been ranged under *Polycope* in the Monograph above mentioned, to a new group. The gradations are noticeable, and the difficulty of getting *perfect* specimens is very great. We therefore now merely record and illustrate the specimen, waiting for better material.

2. CYPROSIS HASWELLII, gen. et sp. nov. Plate IX. Figs. 6*a*, 6*b*.

Length, $\frac{4}{10}$ inch.

The late Mr. G. C. Haswell, of Edinburgh, noticed and figured[1] (indifferently) an interesting and unique internal cast of an Entomostracan valve in olive-grey Upper-Silurian mudstone, from the west side of the North-Esk Reservoir in the Pentland Hills.

This specimen Mr. Haswell kindly allowed me to examine and sketch ; and my view of its characters and relationship is as follows :—

It is a slightly convex cast, representing the left valve of a Cypridinad, naturally indented at the posterior third by a strong transverse sulcus, and by a fainter impression across the anterior third. It is ovate in outline, subacute behind (rather too blunt in the drawing), and distinctly beaked and notched in front.

Regarding the transverse furrows, especially the hinder sulcus, as zoological features, probably of physiological value, I venture to distinguish this form, rare and poor as it is, by a new name, and dedicate it to the memory of its enthusiastic discoverer.

The observations on this specimen recorded by Mr. Haswell are as follow :—At page 42 of his Memoir above mentioned, he says :—" I found on the west bank of the reservoir one specimen of the carapace of a crustacean, different from the preceding [*Leperditia* ?], represented in plate 3, figure 13. It resembles in some respects the more common forms of *Cypridina*. It is probably a new species, and specimens should be looked for." At page 43, he adds :—" Since the above was in type I have received the following letter from Professor R. Jones, with reference to the specimen, plate 3, figure 13 :—" My dear Sir,—Mr. Henry Woodward has kindly sent me a specimen for examination. It is a good and rare fossil, new to me. It is a *Cypridina*, hardly separable from recent forms, such as Baird, Dana, and others have described, as far as the appearance of this mould of one of the carapace-valves will allow us to judge. The vertical indentation across the valve seems to be natural, and may possibly indicate a generic or subgeneric difference. At all events, you would be safe in using it as the basis of a specific name and distinction for the present. *Cypridina* occurs freely in the Carboniferous rocks. Excepting one specimen of an allied form from the Lower [?] Silurian [Budleigh-Salterton pebble], this of yours is the oldest I know. It is preserved in the same way as the *Leperditia* of the Upper Ludlow beds of Shropshire. I congratulate you on having added such a nice fossil to your collection, and on having brought forward so interesting a species for Palæozoic times. I have taken its measurement and outline as a memorandum. Yours very truly, T. Rupt. Jones. [Yorktown, 1865.] To G. C. Haswell, Esq."

3. CYPROSINA WHIDBORNEI, nov. gen. et spec.
Plate IX. Figs. 1–3, and 5.

	Length.	Height.
Size of different specimens, in 20ths of an inch	16	11
	14	9
	8	4

Unlike the two specimens described above, which are mere casts

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[1] " On the Silurian Formation in the Pentland Hills," Edinburgh, 1865, 8vo. pp. 42 and 43, pl. 3, fig. 13.

and rare, this form occurs in a considerable number, and with the test well preserved; but unfortunately no one of the specimens yet met with has the whole margin of either valve quite exposed for examination; and only one specimen with the valves in juxtaposition has been found. Mr. G. F. Whidborne, F.G.S., of Torquay, has discovered twenty-eight individuals of this species in the Middle-Devonian Limestone of Lummaton quarry, a quarter of a mile north of Marychurch, which is on a hill about two miles north of Torquay. The bluish-grey limestone is in some parts made up of Shells, Polyzoans, Encrinites, etc., with a noticeable proportion (in the hand-specimens) of the organisms under notice.

It is a Cypridinad, having strongly convex valves, elongate-oval in form, and with a short transverse (vertical) sulcus at or near the middle of the ventral region. The closed carapace is subcylindrical, rather acute in front, and rounded behind. The dorsal edge of the left overlaps that of the right valve. The beak at the middle of the anterior margin is distinct, though not large, as in Figs. 2 and 3. It is formed, as it were, by a slight, but definite, lateral pinching of the middle of the front end of the two valves, rather than by a notch cut out of their curved and projecting end.

The antero-ventral margin of each valve turns sharply inwards and upwards to a slight extent, and has a feeble marginal hem (exaggerated in Fig. 3*b*, by local distortion). An antero-ventral longitudinal furrow is thus caused in the closed carapace, continuous with the antennal notch. The ventral margins appear to meet without overlap.

The dorsal margin of the right valve is somewhat flattened or bevelled along the hinge-region, with a slight beading where it turns off from the convexity of the valve, and against which the edge of the overlapping valve rests. None of the figured specimens shows this feature well, but the marginal hem continued from the aforesaid angle is shown in Fig. 5*c*.

The short vertical ventral depression or furrow is a distinctive feature, as important as the dorsal furrow in *Cypridella*, and, although not always strongly expressed, it is too persistent to be accidental. The muscle-spot, neatly radiate, is seen in several specimens (for instance, Fig. 2*a*), near the middle of the valve (but rather backward), at the upward termination of the sulcus crossing its ventral region.

The other organisms constituting the hand-specimens of Lummaton limestone in which I have seen the *Cyprosina* are :—

Atrypa aspera.
Athyris ?
Spirifera nuda ?
Leptæna caperata.
Cypricardia.
Glauconome bipinnata ?
Fenestella prisca ?
Aulopora ?
Coral (obscure).
Encrinital joints.

Mr. Whidborne favours me with the following note on the fossils which he has collected in the limestone of Lummaton quarry. "Some of the most noticeable are :—

Brontes flabellifer.
Phacops latifrons.
Hexacrinus interscapularis.
Euomphalus annulatus.

Acroculia vetusta.
Pleurorhynchus aliformis.
Modiola scalaris.
Strophalosia productoides.
Cyrtina heteroclyta.
Atrypa desquamata.
Atrypa aspera.
Spirifera undifera.
Rhynchonella acuminata.
Rhynchonella cuboides.
Retepora prisca.
Hemitrypa oculata.
Smithia Pengellii.
Cyathophyllum.

"The above are only a portion of the species; for instance, of Brachiopods, which are the leading fossils, I have collected considerably more than 30 species, but I cannot give the exact number, as Mr. Davidson is now revising the Devonian lists." Mr. Whidborne intends to publish a detailed list of the palæontology of this interesting Devonian quarry.

4. POLYCOPE DEVONICA, sp. nov. Plate IX. Figs. 4*a*, 4*b*, 4*c*.

Size: length, $\frac{5}{20}$ inch; height, $\frac{3}{20}$ inch.

This species, of which I have seen three specimens, closely resembles *Polycope simplex*, J. and K. ("Monogr. Carbonif. Entom.," 1874, p. 54, pl. 2, fig. 1); but it is much too convex for that species; and it is too oval in outline for *P. Burrovii*, J. and K. (*loc. cit.* fig. 2). These are but slight differences; we know not, however, how much the animals may have differed in their soft parts.

It has been objected by my friend the Rev. Professor J. F. Blake, in "The Yorkshire Lias," 1876, p. 434, that in his opinion our Palæozoic forms do not perfectly correspond with *Polycope* of Sars. The *Carboniferous* may be far back to look for a direct ancestor of a recent Entomostracon: but for the present, at least, I do not see that we can do better than follow the plan we have long adopted of referring the fossil valves to known genera on the strength of their similarities, the soft organs not having been preserved. How very little one Palæozoic Cyprid, of which the limbs are preserved, differed from the existing forms, has been shown by M. Charles Brongniart, in his elucidation of *Palæocypris Edwardsii*, from the Coal-measures of St.-Etienne, "Annales des Sc., Géol." vii. 6, Art. 3, 1876.

Polycope Devonica was discovered in the Middle-Devonian Limestone of Lummaton, Devonshire, by Mr. Whidborne; and it occurs in the same condition as its more abundant associate, *Cyprosina Whidbornei.*

5. LEPERDITIA? DORSALIS (Richter). Plate IX. Figs. 8*a* and 8*b*.

Length, $\frac{1}{14}$ inch (=2 mm.).

Among some specimens of fossil Entomostraca, which my friend Dr. Richter, of Saalfeld, kindly sent to me, in 1874, for examination, together with the *Entomides* described in the "Annals Nat. Hist.," ser. 5, vol. 4, p. 182, etc., September, 1879, is one marked "*B. dorsalis.*" This is here figured in our Plate IX. Fig. 8, but it bears little resemblance to the *Beyrichia dorsalis*, Richter, "Zeitsch. d. Deutsch. geol. Ges.," 1869, p. 774, pl. xxi. figs. 10–13, which there looks something like *Primitia Maccoyii*, J. and H.

The specimen before me is a small internal cast of a right valve, in dark-grey schist.[1] It is oblong; the posterior is more evenly rounded than the anterior end. The valve is gently convex towards the middle. An eye-spot and a slight elevation behind it remind us of *Leperditia* and *Isochilina.* The outline, eye-spot, and deep ventral margin seem to connect this specimen (small as it is) with the former genus; but necessarily the determination is not satisfactory with such a minute test-less cast.

6. ENTOMIS CALCARATA (Richter). Plate IX. Figs. 9*a*, 9*b*, and 10 (injured behind).

Length, $\frac{1}{35}$ and $\frac{1}{30}$ inch.

Another of M. Richter's specimens is a small piece of dark-grey Devonian Limestone from Thuringia, containing (besides fragments of *Cardiola* ? and *Tentaculites*) two minute valves, one right and one left; oblong, boldly rounded at one end (posterior); and rounded, notched, and armed with a prow at the other (Fig. 9). There is especially to be noticed in each valve a curved sulcus, starting from the middle of the straight dorsal edge, and bending round towards the antero-ventral projecting spur or prow.

These are labelled "*C. calcarata,*" and they bear some resemblance to the figures of *Cypridina calcarata*, Richter, in the Zeitsch. der d. geol. Gesellsch.[2] 1869, p. 771, pl. 21, figs. 3–5. A second spur may have projected from the postero-dorsal quarter of the valve (diagonally opposite to the prow), where a mark for its base remains in our Fig. 9*a*; and with this there would be a closer resemblance to Richter's figures.

Possibly a reference of these specimens to *Entomis*, on account of the nuchal furrow, will be correct. We have another spiked or armed *Entomis* (*E. aciculata*, Jones, GEOL. MAG. Dec. II. Vol. I. p. 511, Fig. 4, woodcut), but the shape and the spur differ from those of *E. calcarata.*

On a piece of greenish, fine-grained, Devonian schist, from Thuringia, with numerous variously squeezed individuals of *Entomis gyrata* and *serrato-striata*, are two small oblong casts of *E. calcarata*, which approximate to the foregoing, but are not quite so minute, and have both of the lobes and the dorsal angles more pronounced; the front lobe, also, bears some obscure sculpturing above the prow. The specimen given in Fig. 10 was at first thought to be of a different kind (with two furrows), but the hinder lobe has been partly overlapped by a portion of another valve, and the apparently hindermost lobe is adventitious.

8. PRIMITIA ARMATA (Richter?). Plate IX. Figs. 11*a*, 11*b*.

Length, $\frac{1}{24}$ of an inch.

M. Richter also sent for examination in 1874, together with the so-called "Cypridinæ" (*Entomides*) of Thuringia, two small pieces of dark clay-schist bearing two internal casts and one external

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[1] "*B. dorsalis*" is from the Upper-Devonian schists of Thuringia.

[2] Richter refers also to the "Beitrag z. Paläont. des Thuringer-Waldes," von R. Richter and F. Unger, 1856, p. 37, pl. 2, figs. 36–38 (Denkschr. math.-nat. Cl. k. Akad. Wien, vol. xi.).

mould of the little form here figured (Fig. 11). The valves are Leperditioid in shape and broadly fabiform. The hinge-line is straight and slopes away with a sudden flattish curve in front and behind (an unfigured specimen has the postero-dorsal slope rounder than that in Fig. 11*a*). The ventral margin is boldly convex, but sloping or somewhat flattened at its anterior third, thus making the front end of the valve rather sharper, narrower, or more tapering than the posterior. The surface is nearly flat; but it has a central swelling, and a well-marked tubercle at each end, near the middle of the anterior and posterior borders, respectively. In one specimen the hinder tubercle is nearest to the margin, and in another individual the front tubercle is closest to the edge, therefore their relative position was liable to some variation. These specimens are quite unlike the "*Beyrichia* (? *Leperditia*) *armata,* Zeitsch. der d. geol. Gesellsch. xv." [1863, p. 672, pl. 19, figs. 16–18], to which my friend refers them by his label, and which appears to me, judging from the figures, to belong to the genus *Aristozoe,* of Barrande. The specimens before me are clearly distinct, and are feature-ful enough to deserve cataloguing under a definite name. I do not know, however, where to place them among known forms except in the genus *Primitia;* and the name *P. armata* will be appropriate, whether the *Aristozoe* (?) above mentioned was intended for reference or not. With *P. armata* numerous *Tentaculites* occur in this Upper-Silurian schist from Thuringia.

9. PRIMITIA ? CYLINDRICA (Richter); and another organism.

Two little pieces of dark-grey Upper-Silurian schist, accompanying those above mentioned from Thuringia in 1874, bear some very small, subovate, internal casts, labelled "*Beyrichia subcylindrica,* Zeitsch. der d. geol. Gesellsch. xv. and xvii." At first sight these look like granulated and spined valves of some small Cypridiform Entomostracon; but in one of the specimens the little processes are seen to be cylindrical, and to pass from the convex cast across a narrow intervening space into the surrounding matrix; and therefore they must be casts of cylindrical tubes in some investing shell or test, different from that of the Entomostraca. Moreover, both the processes and the granulation caused by their broken bases are too coarse for the ornament of such valves.

There are also some minute, smooth casts of obscure valves, and many crushed tubes (minute *Pteropoda?*), on this schist. These smooth valves may belong to *Primitia,* corresponding with Richter's smooth variety of his *B. cylindrica* from the Nereiten-Schiefer (Zeitsch. d. d. geol. Ges. vol. xv. p. 671, pl. 19, figs. 13, 14); whilst his prickly variety (*l.c.* fig. 12, and vol. xvii. p. 365, pl. 10, fig. 7) is, according to my view, a totally different organism.

10–13. BEYRICHIÆ (*Silurian*) FROM THURINGIA. Plate X. Figs. 1–6.

These are casts of *Beyrichiæ* from the Upper-Silurian schists of Thuringia, given to me by M. R. Richter, of Saalfeld, in 1857.

10. Fig. 1 is the ordinary variety of *Beyrichia Kloedeni*, M'Coy; such as is shown in the "Mem. Geol. Surv." vol. ii. part i. pl. 8, figs. 17 and 18; and "Ann. Nat. Hist." series 2, vol. xvi. pl. 6, fig. 7. Right valve. Length $\frac{5}{40}$ inch.

10*. Fig. 2 seems to be a right valve of *B. Kloedeni*, shortened by pressure. Length $\frac{3}{40}$ inch.

In the "Zeitsch. d. d. geol. Ges." xv. p. 671, pl. 19, figs. 7–11, and vol. xvii. p. 364, pl. 10, fig. 6, M. Richter has described and figured *Beyrichia Kloedeni* as plentiful in the Upper-Silurian conglomerate and Nereiten-Schiefer of Thuringia. This appears to me to be *B. Kloedeni*, var. *torosa* (A. N. H. 2, xvi. p. 167, pl. 6, fig. 11).

11. Fig. 3 is *B. Wilckensiana*, Jones (*op. cit.* p. 89, pl. 5, figs. 18–20). Right valve. Length $\frac{6}{40}$ inch.

12. Fig. 4 is an obscure cast of the right valve of a *Beyrichia* closely allied, apparently, to *B. affinis*, Jones (*op. cit.* p. 170, pl. 6, fig. 16). Length $\frac{4}{40}$ inch.

13. Fig. 5 is a cast of a right valve, having an approximate resemblance to *B. intermedia*, J. and H. (Ann. N. H. ser. 4, vol. iii. p. 218, pl. 15, fig. 7; and vol. xv. p. 55, pl. 6, fig. 11), from the Upper Silurian of England and the Carboniferous of Russia. Length $\frac{3}{40}$ inch.

11*. Fig. 6 appears to be a large *B. Wilckensiana* (left valve), obliquely squeezed. Length $\frac{6}{40}$ inch.

14. Beyrichia Hollii, sp. nov. Plate X. Fig. 7.

Length, $\frac{1}{20}$ inch.

This *Beyrichia*, represented by a small cast (in pyrites) of the inside of a left valve, has very much of the aspect of *B. intermedia*, J. and H., mentioned above, but it is less truly semicircular, being contracted towards one end (anterior); it has a broader marginal rim; the valleys dividing the lobes, though confined to the dorsal region, are less symmetrical; and the prominent lobe does not appear to be the central, but the posterior lobe. In this last point, however, there is some obscurity, on account of the valve having been somewhat crushed at the posterior third. These differences demand a nominal separation of this from the allied species, and I name it after its discoverer, Dr. H. B. Holl, F.G.S., who on this and other occasions has kindly co-operated with me in working out the Palæozoic Bivalved Entomostraca.

Dr. Holl discovered this unique specimen in Menævian flags from St. Davids, in 1866. It was associated with *Protospongia fenestrata*,[1] Salter, and therefore belongs probably to the horizon of *Paradoxides Davidis*, rather above the Middle Menævian flags of Dr. Hicks's classification.

In the far-remote Menævian Period there were Bivalved Entomostraca, small, but of much interest, especially as being the oldest that we yet know.

1. *Entomidella buprestis* (Salter). "Lower and Middle Menævian," A. N. H. ser. 4, vol. xi. p. 417.

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[1] Quart. Journ. Geol. Soc. vol. xx. p. 238, and xxvii. p. 401.

2. *Primitia Solvensis*, Jones. "Middle Menævian," or rather higher. Ann. N. H. ser. 2, vol. xvii. p. 95, pl. 7, fig. 16; ser. 4, vol. ii. p. 55; and vol. iii. p. 223.
3. *Leperditia Hicksii*, Jones. "Middle Menævian." Q.J.G.S. xxviii. p. 183, pl. 7, fig. 16 (bad). This will be figured again in a forthcoming paper.
4. *Beyrichia Hollii*, Jones. "Middle Menævian." See above.[1]

The close alliance of *B. intermedia* to the last-mentioned may be an illustration of *atavism.* The re-occurrence of these lower kinds of organisms in Upper Silurian, after the Cambrian and the Lower Silurian, is not strange; and we know of the re-occurrence of Upper-Silurian Entomostracan species in the Carboniferous strata,—for instance, *B. intermedia*, as mentioned above, and the apparently Carboniferous species enumerated in the notice of Mr. J. Smith's washings (Geol. Mag. Dec. II. Vol. VIII. p. 75), and known also in Mr. G. R. Vine's collection from Mr. George Maw's washings of the Upper Silurian shales.

15. Beyrichia tuberculata (Kloeden). Plate X. Figs. 8, 9, 10.

Length, $\frac{1}{7}$ and $\frac{1}{6}$ inch.

In his papers on the Geology of Arisaig, Nova Scotia, read before the Geol. Soc. Lond. in 1864 and 1870, the Rev. Prof. D. Honeyman, D.C.L.,[2] referred to some Upper-Silurian Entomostraca from that district. At p. 344, Q.J.G.S. vol. xx. they were quoted as *Beyrichia pustulosa*, Hall; *B. æquilatera*, Hall, *Beyrichia*, 2 spp., and *Leperditia sinuata*, Hall. Some specimens from Arisaig left with me by my friend Dr. Honeyman in 1862 for examination were described in the Q. J. G. S. vol. xxvi. p. 492, as being *Beyrichia tuberculata* (Kloeden); *B. Wilckensiana*, Jones; *B. Maccoyiana*, Jones; and *Primitia concinna* (?), Jones. There are also other *Primitiæ* associated with the foregoing. One resembles *P. ovata*, J. and H. They occur more or less abundantly in a highly fossiliferous dark-grey limestone.

Fig. 8 is an inside cast of a right valve, devoid of the test; the main lobe and the postero-dorsal angle are broken. Fig. 9 shows a perfect left valve; and Fig. 10, a fine right valve, still partly imbedded in the matrix along the dorsal edge In the latter the anterior lobe is not divided into two as it usually is.

Probably these specimens may be the same as the form described by Prof. James Hall and Principal Dawson as *B. pustulosa*, Hall ("Canadian Nat. and Geol." vol. v. p. 158, fig. 19, woodcut; and "Acadian Geol." 2nd edition, p. 608, fig. 216, woodcut); but I find no essential difference between the very fine large specimens before me and the Scandinavian specimens of *B. tuberculata* described and figured in the "Ann. N. Hist." ser. 2, vol. xvi. p. 86, pl. 5, figs. 4–9.

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[1] Some other Menævian fossils have been referred with doubt to Entomostraca, namely, *Leperditia ? vexata*, Hicks. "Lower and Middle Menævian." I think this to be a portion of a larval Trilobite. *Leperditia ? Cambrensis*, Hicks. "Red shales of the Longmynd" group. This seems to me to be quite indeterminable at present. See Q.J.G.S. xxvii. p. 396, and xxviii. p. 184.

[2] Fellow of the University of Halifax, Curator of the Provincial Museum, Provincial Geologist, and Professor of Geology to Dalhousie College and University, Halifax, Nova-Scotia.

16. Beyrichia Kloedeni, M'Coy, var. antiquata, Jones.
Plate X. Fig. 11.

Length, $\frac{1}{6}$ inch.

This fine specimen, in Lower-Ludlow Limestone, collected by the late Henry Adrian Wyatt-Edgell[1] at Leintwardine, near Ludlow, and sent to me for examination, soon after his leaving the Royal Military College, and not long before his lamented death, is a large individual of *B. Kloedeni*, var. *antiquata*, retaining a portion only of the test. This variety was previously known from the Wenlock schists of Montgomery. See "Ann N. Hist." ser. 2, vol. xvi. p. 167, pl. 6, fig. 8. It has also been met with at Blaeberry Burn, Loganwater, Lesmahago; and at Kington, near Ludlow.

17. Beyrichia Kloedeni, M'Coy. Plate X. Figs. 12, 13.

Length, $\frac{1}{20}$ and $\frac{1}{6}$ inch.

Fig. 12 shows the inside cast of a small left valve of *B. Kloedeni*, in a reddish, sandy, fossiliferous mudstone from the Upper Llandovery beds at Howler's Heath, near Malvern. Collected by the late H. A. Wyatt-Edgell, and sent to me with the above.

Fig. 13 is a very fine and well-preserved right valve, with a granulated surface, from the Wenlock Limestone of Benthall Edge, Shropshire. It is the form described and figured by Mr. Salter as *B. tuberculata* (but it is not Kloeden's *Battus tuberculatus*) in the "Memoirs Geol. Survey," vol. ii. part 1, p. 352, pl. 8, fig. 14. This I now refer to as *Beyrichia Kloedeni*, M'Coy, var. *tuberculata* (the "granulated" variety in "Ann. N. Hist." ser. 2, vol. xvi. p. 166, pl. 6, fig. 9).

Owing to the full growth of advanced age the front and hind lobes are not so distinct in this specimen as in the Fig. 9 just referred to, nor as in Figs. 1 and 12 of our present Plate. These conditions are found frequently to occur among the somewhat variable group typified by *B. Kloedeni*, M'Coy.

Note on the Synonymy of the Chief Forms of British *Beyrichia Kloedeni*.

I. Beyrichia Kloedeni typica.

Beyrichia Kloedeni. M'Coy, Synops. Sil. Foss. Ireland, 1846, p. 58, woodcuts.
,, ,, ,, Brit. Pal. Foss. Cambridge, 1851, part 2, fasc. 1. p. 135, pl. 1 E. fig. 2.
,, *gibba*, Salter, Mem. Geol. Surv. 1848, vol. ii. part 1, p. 352 (*gibbosa* at p. 234), pl. 8, figs. 17, 18.
,, *Kloedeni*, Jones, Ann. N. Hist. 1855, ser. 2, vol. xvi. p. 166, pl. 6, fig. 7 (smooth valve); Pal. Biv. Entom., Geol. Assoc. 1869, pp. 11 and 14, figs. 6*a*, 6*b*.

II. B. Kloedeni, var. tuberculata [Sow. or Salter].

Agnostus tuberculatus, Sow. or Salter, in Murchison's Sil. Syst. 1839, p. 604, pl. 3, fig. 17. Not Kloeden's *Battus tuberculatus*.
Beyrichia tuberculata, Salter, Mem. Geol. Surv. 1848, vol. ii. part 1, p. 352, pl. 8, figs. 14, 15. (Fig. 14 has the same form, but no granulation, and may have been intended for an internal smooth cast of a tuberculate valve.)

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[1] This promising young officer of the 59th, and subsequently of the 13th Regt., died at Belfast in 1866.

Beyrichia tuberculata, Salter, in Siluria, 1854, p. 234, woodcut 45,4 (1867, woodcut 64,4).

B. Kloedeni (with granulated surface), Jones, Ann. N. H. 1855, ser. 2, vol. xvi. p. 166, pl. 6, fig. 9.

III. Other varieties :—

B. Kloedeni, var. *antiquata*, Jones, Ann. N. H. *loc. cit.* fig. 8; Pal. Biv. Ent. Geol. Assoc. 1869, pp. 12 and 14, fig. 7.
,, var. *pauperata*, Jones, Geol. Assoc. 1869, pp. 12 and 14, fig. 8.
,, ,, *intermedia*, Jones, *Ibid.* fig. 9.
,, ,, *subtorosa*, Jones, *Ibid.* fig. 10.
,, ,, *torosa*, Jones, A.N.H. *l.c.* figs. 10 and 11, 12 (?); Geol. Assoc. *l.c.* fig. 11.

14. Beyrichia Colwallensis, Holl, MS. Plate X. Figs. 14*a*, 14*b*.

Length, $\frac{1}{20}$ of an inch.

Carapace semi-cordate; length nearly twice the depth. Dorsal margin straight; ventral margin obliquely curved; anterior extremity pointed; posterior extremity obliquely rounded. A sharp keel extends from the anterior extremity round the ventral margin to the posterior dorsal angle; and parallel to the keel, and at a short distance from it, there is a sharp rim, which extends from one dorsal angle to the other. Between this rim and the keel there is a narrow groove, which is broadest at the postero-ventral curve, and narrows towards each angle. The lateral surfaces are divided midway between the two extremities by a broad, rather shallow, sulcus, which extends from near the dorsal line half-way across the valve, and is bordered on either side by an oval lobe; the ventral extremities of which are connected by a curved ridge, forming a horseshoe-shaped elevation, from which the sides slope gradually towards the marginal rim.

Length, $\frac{60}{1000}$; depth, $\frac{35}{1000}$ of an inch.

Only two examples of this species have been met with: the one that is figured, and a small (young) individual, having the same characters.

B. Colwallensis was found by Dr. H. B. Holl, F.G.S., in the shaley bands interstratified with the Woolhope Limestone in a quarry below the Wych, Malvern, in the hamlet and parish of Colwall, whence the name of this new species.

EXPLANATION OF PLATES IX. AND X.

PLATE IX. (Figs. 1-5 are from the Middle-Devonian Limestone of Lummaton, near Torquay.)

Fig. 1.—*Cyprosina Whidbornei*, Jones, nov. Right valve. Magnified 2 diameters. The antero-dorsal edge, including the beak, is broken in the original and not fully restored in the figures 1*a* and 1*b*. The little nick at the posterior end, caused by a slight crush, was at first mistaken for the remains of a beak.

a. Lateral; *b.* dorsal; *c.* posterior view. The little nick here is a fracture, not the trace of a beak.

,, 2.—*C. Whidbornei*, Jones, nov. Anterior moiety of a left valve, with beak and muscle-spot well preserved. Natural size.

a. Lateral; *b.* anterior view.

FIG. 3.—*C. Whidbornei*, Jones, nov. Left valve; imperfect in the dorsal region, and somewhat crushed at the ventral sulcus. Natural size.
a. Lateral; *b*. ventral; *c*. anterior view. The antero-ventral edge accidentally protrudes in 3*b*.

,, 4.—*Polycope Devonica*, Jones, nov. Left valve. The upper (dorsal) edge should be rather less convex in outline. Magn. 2 diam.
a. Lateral; *b*. ventral; *c*. anterior view.

,, 5.—*Cyprosina Whidbornei*, Jones, nov. Right valve. Nat. size. The muscle-spot is present, though obscure, at the top of the ventral sulcus.
a. Lateral; *b*. dorsal; *c*. posterior view.

,, 6.—*Cyprosis Haswellii*, Jones, nov. Left valve. Nat. size. From the Upper Silurian of the Pentland Hills.
a. Lateral; *b*. ventral view.

,, 7.—*Cypridina* ? Internal cast of a right valve. Magn. about 4 diam. From a pebble of Palæozoic quartzite in the Triassic Conglomerate of Budleigh-Salterton, Devon.
a. Lateral; *b*. dorsal view.

,, 8.—*Leperditia ? dorsalis* (Richter). Inner cast of a right valve. Magn. 25 diam. From the Upper Devonian of Thuringia.
a. Lateral; *b*. ventral view.

,, 9.—*Entomis calcarata* (Richter). Inner cast of a left valve. Magn. 25 diam. From the Devonian Limestone of Thuringia.
a. Lateral; *b*. ventral view.

,, 10.—*E. calcarata* (Richter). Lateral view of an internal cast of a left valve, injured behind and overlapped by part of another valve. Magn. 25 diam. In Devonian schist, with other *Entomides*, Thuringia.

,, 11.—*Primitia armata* (Richter ?). Inside cast of a left valve. Magn. 25 diam. In Upper Silurian schist, with Tentaculites, from the Thüringerwald.
a. Lateral; *b*. dorsal view.

PLATE X. FIGS. 1-6. Upper Silurian *Beyrichiæ* from the Thüringerwald. Magnified 4 diameters.

FIG. 1.—*Beyrichia Kloedeni*, M'Coy. Gutta-percha mould of a hollow impression (external cast) of a right valve.

,, 2.—*B. Kloedeni*. Internal cast of a right valve, shortened by having been squeezed endwise.

,, 3.—*B. Wilckensiana*, Jones. Inside cast of a right valve.
a. Lateral; *b*. ventral view.

,, 4.—*B. affinis* (?), Jones. Inside cast of a right valve.

,, 5.—*B. intermedia* (?), Jones and Holl. Inside cast of a right (?) valve.

,, 6.—*B. Wilckensiana* ? Inside cast of a left valve, obliquely squeezed.

,, 7.—*B. Hollii*, Jones, nov. Pyritous internal cast of the left valve. Magn. 23 diam. From the Menævian flags of St. Davids, South Wales.

,, 8.—*B. tuberculata* (Kloeden). Internal cast of right valve, imperfect at the antero-dorsal corner and at the posterior lobe. Magn. 11 diam. Upper Silurian limestone; Arisaig, Nova-Scotia.

,, 9.—*B. tuberculata* (Kloeden). Left valve, well preserved. Magn. 11 diam. Arisaig.

,, 10.—*B. tuberculata* (Kloeden). Right valve; partly imbedded along dorsal edge. Magn. 11 diam. Arisaig.

,, 11.—*B. Kloedeni*, M'Coy, var. *antiquata*, Jones. Cast of right valve, with a remnant of the prickly margin of the smooth shell. Magn. 11 diam. Ludlow beds of the Upper Silurian; Leintwardine, Shropshire.

,, 12.—*B. Kloedeni*. Internal cast of a small left valve. Magn. 23 diam. Upper Llandovery beds; Howler's Heath, Malvern.

,, 13. *B. Kloedeni*, var. *tuberculata* (Salter). Large right valve, well preserved. Magn. 23 diam. Wenlock Limestone; Benthall Edge.
a. Lateral; *b*. ventral view.

,, 14.—*B. Colwallensis*, Holl MS. nov. Right valve. Magn. 20 diam. Woolhope shale; near Malvern.

II.—How to Work in the Archæan Rocks.

By C. Callaway, M.A., D.Sc. (Lond.), F.G.S.

THE Archæan (Pre-Cambrian) rocks of Britain have of late years received considerable attention, owing partly to the more or less complete working out of the younger groups, and partly, perhaps, to the fascination which attends a study of peculiar complexity. Whatever interest attaches to the correlation of formations which can be easily identified by their organic remains, or which can be traced across country for scores of miles in unbroken lines, it will be readily understood that the spirit of inquiry will be strongly piqued when it is challenged to construct orderly systems out of rock-masses to which the ordinary tests can be but partially applied. Yet much has been done towards the establishment of a succession amongst these ancient groups. In America, Dr. Sterry Hunt describes six distinct systems. These, taken in descending order, are the following:—

I. *Keweenian*, or Copper-bearing series of Lake Superior.
II. *Taconian*. Perhaps the same as I.
III. *Montalban*, or Mica-schist series.
IV. *Huronian*, or Green Mountain series.
V. *Norian*, or Labradorian.
VI. *Laurentian*.

Some of these groups are undoubtedly established, while others are not undisputed; but should this succession, or the major part of it, be ultimately received, it is evident that we shall have, underlying the "bottom rocks" of Murchison, a group of rock systems of at least equal value to any of the three great divisions:—Palæozoic, Mesozoic, and Cainozoic.

The study of these old groups has also made considerable progress in the British Islands. Murchison recognized the Laurentian in the great gneiss series of the Hebrides and the north-western Highlands, and Dr. Holl claims the same antiquity for the metamorphic ridge of the Malvern Hills; but the discoveries of Mr. Salter and Dr. Hicks at St. Davids have given the chief stimulus to these investigations. The two recognized formations worked out by Dr. Hicks, the Dimetian and the Pebidian, furnish us with a clue to unravel the complexities of some other districts. The probable equivalents of these groups have been identified in Caernarvonshire. Anglesey is mainly occupied by two Archæan series, one of which is clearly Pebidian, while the other, a great gneissic formation, may possibly be Dimetian. The Malvern gneiss group has been identified in the Wrekin, while the same mountain and many other Shropshire hills are mainly built up of bedded lavas and ashes which may be Pebidian, and are certainly Archæan. Pebidian rocks occur in the Herefordshire Beacon, near Malvern; and the Charnwood slaty series probably belongs to the same group.

The difficulties attending these investigations are so great that some of the older geologists have expressed much scepticism on the possibility of arriving at satisfactory conclusions. At the outset we are met by the almost entire absence of fossils. In the British Islands not a single organism, or trace of organism, has been detected in undoubted Archæan rocks. Besides this, the excessive contortion which many of these ancient deposits have undergone has sometimes proceeded so far as to invert the succession, the older rocks overlying the younger. In some cases metamorphism has been so extensive as to entirely obliterate all trace of bedding. To crown all, Archæan districts are usually shattered by faults, fragments of various formations being thrown together in the wildest confusion, as if the mythical giants who heaped Pelion and Ossa on Olympus had been playing at bowls with torn-up fragments of the earth's pavement. Notwithstanding these difficulties, despair of success would be fatal to scientific progress, and what has been done is a sufficient encouragement to further investigation. It is proposed in this paper to examine how far the usual tests of geological age are applicable to these altered and broken formations.

The evidence of *organic remains* is usually of first importance, but here it is rarely applicable. The testimony of *Eozoon Canadense* will of course occur to every one. But here we are met by two questions: 1. "Is *Eozoon* organic?" 2. "If organic, is it characteristic of any one horizon?" The answer to the first question must be, in the writer's opinion, "Not proven." The most eminent specialists cannot agree in their conclusions. Writer after writer arises with the assured conviction that he has settled the matter, yet the matter refuses to be settled. Whatever may be the ultimate conclusion of science—if such a goal be ever reached—it is obvious that, so long as the organic nature of *Eozoon* remains undetermined, the structure can possess no decisive value for classificatory purposes. But, admitting that *Eozoon* is a true fossil, is it characteristic of any one epoch? Is it Laurentian, and Laurentian only? The researches of American geologists tend to prove that such is not the case. In Hastings County, Ontario, is a great series of "slates, quartzites, conglomerates, and limestones." These rocks are said to rest unconformably upon the edges of both the Laurentian and the Huronian, and the conglomerates contain pebbles supposed to be derived from those formations. In the upper part of the series are "fine-grained, greyish, more or less schistose, and earthy limestones, containing *Eozoon*." This group is referred to the Taconian, one of the higher Archæan formations. This succession was worked out by Mr. Vennor, and adopted by Dr. Sterry Hunt. The lithology of the rocks is widely different from either the Laurentian or the Huronian, and there seems no sufficient reason to doubt their posterior age. Accepting this view, the value of *Eozoon Canadense* as a test of contemporaneity is at once destroyed. The late Sir R. I. Murchison felt no difficulty in admitting that the fossil might even be "Lower Silurian." When it was announced that *Eozoon* had been found in the serpentinous marble of Connemara, he said:—"Even if it should be proved that the foraminifer is present, its occurrence would in no wise affect my conclusion that the rock is Lower Silurian." "Creatures of that low type of life may well have lived on from the Laurentian to the Lower Silurian epoch." Without stretching our faith quite so far, we may readily admit that such lowly organisms have no very decisive stratigraphical value.

Besides *Eozoon*, certain other traces of animal life have been quoted from Archæan quartzites and limestones. They are generally tracks or perforations such as may have been made by worms crawling over the surface of sand or calcareous mud, or boring for themselves vertical or curved burrows. Such evidences of life are found abundantly in many subsequent formations, and they do not materially differ from the tracks and burrows which abound on the sea-shore at the present day. They are therefore of but slight value in the correlation of rock-groups.

We come next to the second test of contemporaneity, *order of superposition*. This also can only be applied in some cases. *Inversion* is not at all infrequent in these old rocks. The beds are sometimes bent up into a series of folds, compressed so closely as to be almost vertical, and the tops of the arches are thrown over in one direction, so that the strata seem to dip regularly to the same point of the compass. These phenomena are sometimes seen in Palæozoic or even Neozoic formations, but they are much more common in the Archæan groups. In the United States large tracts of country are occupied by gneiss with a prevailing south-east dip, but really made up of numerous parallel folds with their summits thrown over to the north-west. The contorted schists of Anglesey display the same phenomena. In the region to the north-west of the Menai Straits, these repetitions by folding falsely suggest a great thickness of strata. The true relations of the beds are only to be ascertained by disentangling the complications. The key to the solution of the difficulty is the discovery of a grey gneiss underlying the prevailing dark green schist of the district. As the strata roll over, the grey band is here and there brought up to the surface, flanked on each side by the green schist, which is seen to lie on the gneiss in sharp synclinal folds, and the thickness, which is not great, can be thus ascertained.

Another difficulty in the application of the superposition test is the excessive *faulting* which Archæan rocks have suffered. In some areas, these old formations had been heavily fractured even before the Cambrian period, and they have of course been exposed to all the dislocations which have subsequently rent the crust. Those who are familiar with field-work only in the south or east of England would feel strange on one of the Archæan battle-grounds, where fire and water have contended which should most effectually remove the traces of the original structure of the rocks; but the tangled maze of faults which have sliced and broken the crust would be found the greatest stumbling-block to success. At St. Davids, happily, the Lower Cambrian rests upon the upturned edges of the Pebidian, and the Archæan age of the latter is thus distinctly proved, but such clear evidence of infraposition is rarely to be obtained in this country. In the Malverns, the Archæan ridge is pushed up between a pair of faults, and in no spot do the Cambrian or Silurian rocks clearly rest upon the older series. The structure and relations of the Wrekin in Shropshire are similar. In Caernarvonshire, on Llyn Padarn, near Llanberis, Cambrian conglomerates are in contact with an older group, but the junction appears to be a fault. In Anglesey, the newer Archæan series, the Pebidian, is faulted against both the Cambrian and the gneiss group.

Nowhere will the student who is fond of faults find a happier hunting-ground than in Anglesey. In a morning's walk, he will probably meet with more dislocations than men. The Geological Survey Map displays a network of earth-fractures, but where the surveyors have put in one, they have sometimes overlooked two. The more attentively and closely the ground is studied, the more frequently do faults appear.

The difficulty from faulting may often be overcome by the following method. To make the matter clearer, an actual example will be taken. In Central Anglesey there is a band of granitoid rock (*f*), coloured pink on the Survey Map, passing down into a dark-coloured schist (*e*), which rises up into an anticlinal arch (seen at the west end of the section, Fig. 1), throwing off the granitoid beds on both sides. But in this area we can find no strata below the schist, and when we follow the rocks towards either the west or east, we come to a fault (*F*1, *F*2). However, on searching the ground to the east, we light upon the dark schist, forming a parallel band about two miles from the granitoid zone. Then working along the sea-coast to the west, where the rocks are clearly exposed in the cliffs, we see that the dark beds are underlain by a considerable thickness of grey gneiss (*d*), under which is a thin band of crystalline limestone (*c*), followed in succession by quartz-schist (*b*), and, at the base of the section, by hälleflinta (*a*). This brings us back again to the fault (*F*2). It might at first sight seem as if this fault broke the succession, and that it was useless to pursue the inquiry;

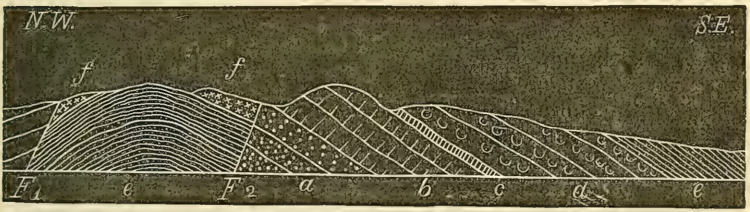

Fig 1. Section in Central Anglesey, showing proof of the gneissic succession.

a. Hälleflinta.
b. Quartz-schist.
c. Limestone.
d. Grey gneiss.
e. Green schist.
f. Granitoid rock.

*F*1, *F*2, Fault.

but such a conclusion would be premature. It is quite clear that the dark schist (*e*), which is found to the east of the fault, is the same band as that which underlies the granitoid rock (*f*) in the anticlinal. It therefore forms a link connecting the two areas, and enables us to piece together the rocks on each side of the fault into a continuous series, *a*, *b*, *c*, *d*, *e*, *f*. In other parts of Anglesey sections have been discovered which confirm this conclusion; so that the gneissic rocks of this shattered district, instead of being regarded as a confused tangle of gnarled schist, are reduced to an orderly succession. The method, then, by which we may often obtain results in shattered districts is:

(1). Ascertain clearly where the faults lie.
(2). Find out the succession in the unfaulted areas.
(3). Compare the unfaulted areas. If one or more rock-groups are common to two or more areas, a satisfactory result may often be obtained.

The test by *included fragments* is of limited value. It simply proves that the beds containing the fragments are newer than the rock which supplied the fragments. In the younger formations this test is altogether subordinate to the more decisive and precise testimony of fossils, but where fossils are wanting it is often of great use. If we found two formations in proximity, one a quartzite containing *Pentamerus oblongus*, and the other a shale with *Ammonites bifrons*, we should at once assign the groups respectively to the May Hill Sandstone and the Upper Lias. If the shale contained pebbles of quartzite resembling the May Hill quartzite, we should hardly trouble to notice the fact. The pebbles, if really derived from the Silurian quartzite, would only prove that the shale was of any age between the Silurian and the Recent.

In studying the Archæan rocks, we often gain a great point if we can prove that one group is newer than another. In Shropshire we have two striking examples of the value of the test of included fragments. Running through the heart of South Shropshire to the south-west is a broken chain of wedge-like hills, of which the Wrekin and Caer Caradoc are the most prominent. These ridges are mainly built up of volcanic ashes and lavas. On both sides they are bounded by faults; numerous formations, from the Lower Cambrian to the Lower Trias, being thrown against them. The evidence from superposition is therefore indecisive. But in the Longmynd (Lower Cambrian) hills, we find massive plum-coloured conglomerates made up of pebbles, some of them as large as a child's head, most of which are a purple felstone identical in character with one of the common types of the volcanic series. Plum-coloured sandstones overlie and underlie the conglomerates, and these rocks also are made up chiefly of grains of the same felstone, with a small proportion of quartz. It is thus evident that a considerable part of the Lower Cambrian series in Shropshire has been derived from the Wrekin volcanic group, which is in this way demonstrated to be Pre-Cambrian or Archæan.

The second example is of equal interest. At the south-western end of the Wrekin ridge is a conical elevation, called Primrose Hill, composed of metamorphic strata, a brick-red granitoid rock, composed mainly of red felspar and quartz, interbedded with hornblendic gneiss and granulite, being the predominant type. These beds dip to the north-east, and seem to pass unconformably beneath the volcanic series which dips to the north; but it is most probable that the junction is a fault; and if so, we have no evidence at this spot of the relations of the two formations. But at Charlton Hill, about two miles to the west, the most satisfactory proof is to be found. Striking east and west through the middle of the hill, and clearly interbedded with tuffs of the volcanic series, is a most interesting conglomerate, containing pebbles of nearly twenty different varieties of rocks, chiefly metamorphic. Amongst these are all the prevailing types found in Primrose Hill, and it is impossible to avoid the conclusion that the conglomerate was derived from a metamorphic group of which Primrose Hill is a denuded fragment. Thus the existence of a second Archæan system in Shropshire is proved. As the Primrose Hill beds are probably the equivalents of the Malvern gneiss, the Shropshire Archæan volcanic series is brought into relation with that group.

Another interesting example occurs in Anglesey. The conglomerates which lie low down in the Cambrian rocks of the island, and which, by their fossils, are proved to be of Tremadoc age, are mainly derived from two older formations, the gneissic and the slaty series. West of Llanfaelog, these conglomerates are associated with fossiliferous grits, and contain pebbles of granitoidite, and of green and purple slate, with other types common in the two altered series, which are thus shown to be Archæan. From such examples as these the testimony of included fragments is shown to be of great value in certain cases.

But this test must be used with caution. In volcanic formations, conglomerates may be derived from lower beds of the same series. If, for example, a stream of lava from Mount Ætna were to reach the sea and become consolidated, the waves might undermine the newly-formed rock, break up the fallen fragments, and round them into pebbles. Thus a shingle-bed would accumulate, and this might, by the addition of cementing matter, become a conglomerate. Pebbles of quartz or any other rocks which were in the vicinity might be mixed up with the lava shingle. If the volcano grew, this conglomerate in process of time would probably be covered in by new lava-flows, or by beds of ashes ejected from the crater. Such conglomerates occur in the Wrekin volcanic series. The pebbles are usually a purplish felsite, but a small proportion of them are of quartz. These beds are obviously produced by contemporaneous denudation, and the included fragments of lava are of no value in classification.

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

III.—ON THE OCCURRENCE OF *MEGACEROS HIBERNICUS*, OWEN, IN THE ANCIENT LACUSTRINE DEPOSITS OF IRELAND; WITH REMARKS ON THE PROBABLE AGE OF THESE BEDS.

By W. WILLIAMS.

THE old lacustrine deposits of Ireland do not seem to have attracted so much attention from geologists as they deserve. By the old lacustrine deposits, we understand the dried-up lakes at present occupied by peat-bogs, with their underlying beds of marl and clays. During the past century it was known that in these bogs, or in the marl-beds beneath them, were found antlers and bones of a gigantic extinct deer, which Professor Owen named *Megaceros Hibernicus*, and now popularly known as the "Irish Elk,"[1] not that it was exclusively confined to Ireland, its remains having been found in England and Scotland, also in France and Germany, and it is even reported to occur in caves as far east as the Altai Mountains in Asia.

Much of the information we have on the subject is oral or traditional, having been obtained from peasant labourers, who (especially in the Co. Limerick) have been long employed to collect these remains for dealers; hence our knowledge on the subject is vague, and in some respects inaccurate.

We are told that the bones of this great animal are found in the bogs of Ireland, the term bog being generally applied to our peat deposits; but as far as I know, they have never yet been actually found in peat. They are always found in the beds of clay or marl which underlie the peat. By some it has been supposed to have survived almost down to recent times. Thirty years ago some Dublin writers even asserted that it was one of the domestic animals of the ancient Irish, and was kept to give milk. Another idea was that, because its bones were sometimes found in considerable quantities in small lake-basins, it must have perished in herds. Again, where the heads of these animals were found totally detached from the bones, it was inferred that the bodies had been eaten by man, and the heads had been thrown into these small lakes, where they were covered up. Or at the time these bogs were marshes, it was believed that the animals by some means were mired in them, and dying, their bodies sank to the bottom.

It was generally supposed that the animal was exterminated by early man. This may have been so on the Continent; but if it can be proved that climatic changes took place in Ireland so as to render it unfit for its existence, then it becomes probable that change of climate was the cause of its extinction here. Such are a few of the vague, and as it appears to me erroneous, ideas entertained on the subject. To dissipate these and to establish more correct conclusions is the object of this paper.

In the year 1876 I was first engaged in explorations. My object was not primarily scientific research. Being a Natural History

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[1] The term "Elk" is calculated to mislead, as it is not an *Alces* or Elk at all, but a true *Cervus*. "Gigantic Irish Deer" would be the more correct name for it.

Preparator, I was desirous to obtain specimens to set up for sale. But I was further desirous to know something of the circumstances under which these remains were found. As a commercial speculation my work was successful. Of the result of my scientific observations and conclusions others must judge. In the years 1876-77 I spent ten weeks excavating Deer-remains in the bog of Ballybetagh; subsequently I have made similar excavations in the counties of Mayo, Limerick, and Meath; so that I am not without some experience in this matter.

It may be premised that these peat-bogs occupy the basins of lakes, the deeper hollows of which have long since been silted up with marls, clays, and sands, and on this silt or mud the plants which produced the peat grew. I find a general resemblance in the order of succession of the beds in all the bogs I have examined; variations in the infilling materials and other circumstances will account for any local diversity that may exist when comparing one locality with another.

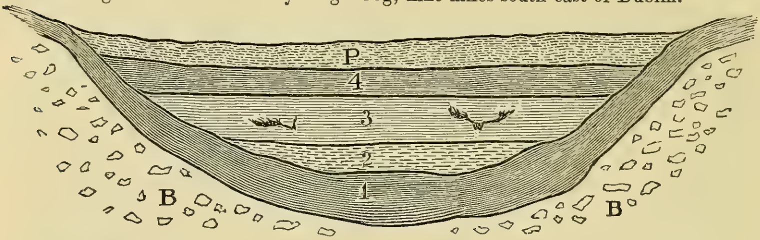
The examination of these deposits is of interest not only on account of the remains of these fine animals which they yield, but also because I believe these beds afford the most reliable record we have of the changes of climate that have occurred, not in this country alone, but also over the whole northern hemisphere, from the close of the great Glacial Epoch to the time of the covering up of these silted-up lakes by the growth and accumulation of peat.

In treating the subject we shall describe the Bog of Ballybetagh, and take it as a type of the bogs throughout the whole country. I select Ballybetagh, because it was there I arrived at the conclusions here advanced; and having spent ten weeks in making excavations, I have an accurate knowledge of it. It was moreover the scene of one of the excursions made by the British Association in 1878. Prof. W. Boyd Dawkins refers to the visit in his new book, "Early Man in Britain; or Man's Place in the Tertiary Period."

Ballybetagh Bog is situated in a small valley, lying between some outlying hills south-east of the Three Rock Mountains, about nine miles south-east of Dublin, at an elevation of about 800 feet above the sea-level, and is bounded east and west by low granite hills, the valley itself running north and south, where it is intersected by the Glencullen river. Two small lakes occupy the bottom of this valley, forming something like the figure ∞. The larger loop occupies the northern end, the smaller one lying towards the south, at a higher level, but connected with the northern lake, and receiving its overflow, which it discharges into the Glencullen river. The *Megaceros* remains have been found mostly in the smaller lake. Both of the lakes have been silted up, and are now pasture-land.

Having described the locality, one point is worthy of notice: its elevation prevented it from receiving the drainage of any long sweep of country; hence there could not have been a rush of water through it, and the clays could not have been imported into it from a distance; consequently they must have been brought down from the hills that immediately surround the valley, and, as their surface would hardly measure more than 100 acres or so, the catchment-basin for the reception of rainfall was very limited.

Diagram-section of Ballybetagh Bog, nine miles south-east of Dublin.



P = Peat.
4. Greyish clay, mineral debris from granitic hills brought down by frost, ice, and rain, during the last cold period.
3. Brownish clay, with remains of *Megaceros*.
2. Yellowish-grey clay, almost wholly composed of vegetable matter.
1. Fine tenacious clay (reconstructed Boulder-clay), without stones, brought down by rain-wash from the hills, after the great Glacial Period.
B = Boulder-clay resting on granite, thickness unknown.

We shall now describe the appearance of the clays. On making an excavation we first pass through a layer of peat, about two feet thick, containing occasionally prostrate trunks of oak and alder. We then enter on a bed of greyish clay, which is marked No. 4 in the section; this bed is about thirty inches thick. Beneath this we come to a bed of brownish or snuff-coloured clay (No. 3), in which we find *Megaceros* remains. This clay differs in a marked manner from No. 4, which intervenes between it and the peat, inasmuch as it has all the appearance of a true lake sediment, consisting mostly of vegetable matter. Under No. 3 bed we come to No. 2 clay, which seems to be composed entirely of vegetable matter, as if a heavy crop of grass had been mown and sunk to the bottom of the lake, and had there been subjected to considerable pressure till it became a compact mass, having a yellowish-grey colour, and cutting almost like cheese. Lastly, we come to clay No. 1, which forms the substratum of the entire lake-basin. This clay is exceedingly tenacious, and it was in this clay, as I conceive, that the *Megaceros* got mired; it is such as is used by brick-makers. Near the margin it thins out, but deepens to a considerable thickness near the centre of the lake, and rests upon true Boulder-clay.

Having thus briefly described the argillaceous deposits observed at Ballybetagh, and having stated that a general resemblance exists between them and those of lake-beds in other parts of Ireland, it might be well to notice in what respect they differ. One marked difference is that Ballybetagh lies in a granitic district, and all the mineral matter is granitic, having been brought down mechanically from the surrounding hills. Marls are usually found in the Carboniferous limestone districts, and result from a chemical dissolution of the limestone rocks by carbonic acid brought down with the rain-water in solution, and afterwards carried into the lakes there. Parting with a portion of its carbonic acid, the lime falls to the bottom, and, mixing with the organic matter, forms marl of different degrees of purity, owing to the quantity of clayey matter mixed with it. In some instances the solution is taken up by the freshwater mollusca to form their shells, which, after their death, accumulate in the lakes and becomes shell-marl. In Kildare and Meath the latter is more abundant than in the Limerick lake deposits.

Let us endeavour to trace the history of the silting up of an Irish lake, taking Ballybetagh as an example. Going back to the close of the great Glacial Epoch, let us examine the state of things that then existed, taking this as our starting-point.

It is an admitted fact among geologists that at the time of the great Glacial Epoch, or as Dr. Geikie calls it "the Great Ice Age," the whole surface of the Northern hemisphere was covered with immense glaciers, which, like those of the Arctic regions at the present day, moved over the land, but were even more extensive. Some writers affirm that they must have been miles deep at the pole, but thinned off down to the 40th degree of latitude. There is evidence that they flowed over the "Three Rock Mountains," 1200 ft. high, only two miles from the bog that has been described. This tremendous moving force ground down the rocks of the country, leaving scorings on them which can be seen at the present day. To this grinding force we are indebted for the mineral ingredients of our soils, consisting as they do of pulverized rocks.

In the case of Ballybetagh a glacier, or a part of the ice-flow, seems to have passed over a hill that lies to the north-west of the valley, and, descending it, displaced the matter that previously occupied the hollow and pushed it on towards the south-east, leaving at its exit a bank or dam of Boulder-clay, so that the waters of the lake were kept at a higher level than that of the bog at present. The old water-line can still be traced along the hill-sides. Here we have a lake formed; the surrounding slopes, after the climate became milder, and the glaciers were melted away, were covered with a coating of tenacious Boulder-clay, full of erratic and loose stones.

During the thaw the climate was intensely humid. The valleys were filled with turbid water, and the rainfall, acting on a land-surface perfectly denuded of vegetation, brought down the fine particles of the Boulder-clay into the lake, leaving the gravel on the hills, so that in the lake-bed we have a sort of geological paradox, Boulder-clay without Boulders.[1] This process, no doubt going on for a long period, fully accounts for the deep bed of tough clay No. 1. It seems to have been the clay in which the *Megaceros* got mired and trapped, similar natural traps being spread over the country wherever these lakes occur.

Clay No. 2 can hardly with propriety be called a clay. It is, as stated, a bed of pure vegetable remains, that has been ages under pressure. As the climate improved, and the cold of the Glacial period had passed away, vegetation commenced in the bottom of the

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[1] This would properly be described as *reconstructed* Boulder-clay.

lakes, evidenced by the luxuriant bed of vegetable matter which we find resting on the fine Boulder-clay rain-wash just noticed. The total absence of the latter clay No. 1 in this vegetable bed indicates dryness of climate; the summers must have been unusually warm and dry, and favourable to vegetation. Such summers may well have brought back our flora and fauna to places where now their remains are found. Probably at this time the Hippopotamus and Rhinoceros made their way into Yorkshire, and the Lion and Hyæna left their bones in the caves of England.

The reclothing of these lands with vegetation must have been an exceedingly protracted process. The hills were covered with stones and rock-debris, the soil was destitute of humus or decayed vegetable matter, in winter a pasty clay, in summer like a sun-dried brick. The total absence of all seeds of plants, ages of low temperature, and the grinding of immense glaciers, had utterly destroyed all traces of vegetation, except of arctic plants, which may have existed in some favoured spots. The only vegetation suited to this state of things would be Cryptogamic plants; lichens and mosses would diffuse their spores most rapidly; the growth and death of these, combined with atmospheric influences, would in the lapse of years ameliorate the soil, and prepare it for the grasses, etc., which, by their light seeds and rapid growth, would soon diffuse themselves and cover the land with prairie. Whilst this was going on the luxuriant vegetable growth was proceeding in the lakes, leaving the plant-bed forming Clay No. 2.

About this time the *Megaceros* appeared in Ireland. For resting on this vegetable bed we first find its remains. How long it may have previously existed on the Continent I will not say: it may have lived in pre-Glacial times, and escaped extinction by migrating south; it is its presence here with which we have to do; the geographical conditions which made it possible for it to reach Ireland I will not attempt to discuss here. The question now arises, "How did it get drowned?" It may have gone into the lakes to escape wolves, or possibly to escape man; but the evidence of the presence of man with the *Megaceros* in Ireland is very slender indeed; the finding of human bones stated to be associated with those of the *Megaceros* in the small cave at Cappagh, Co. Waterford, looks like it, but is not considered conclusive.

It may be that the animals went into the lakes to wallow, as is usual with Deer, or it may have been that the animal, when passing over the country, boldly ventured to ford the rivers or swim across small lakes. It was easy enough to get into the lake; but when it swam across and attempted to get out at a shore having an incline of nearly 45 degrees, composed of tough clay above 6 feet deep (we know not how much more[1]) which lined the lake-basin, into which when their small feet were thrust, no bottom could be found, the more they plunged and struggled the worse they became, till at last the heavy antlers (60 or 70 pounds in weight) pressed

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[1] An iron rod, ten feet in length, pressed through this clay found no bottom rock.

the nose of the animal under water and so ended its life. It may be objected, "If this theory be true, we ought to find the shanks of the animal sticking in the stiff clay described." This does not follow. Suppose the animal did remain in this position for a few days, the motion of the waters of the lake, acted upon by the wind, would sway the body to and fro, causing the water to penetrate around the legs of the deer in the tough clay, whilst the gases developed by putrefaction in the animal's body would render it buoyant and tend to raise it bodily off the bottom, whilst the lake, swelled by rain, would add its lifting power and soon draw the legs out of the clay, and the body would be left free to drift before the wind to the lee-side of the lake, its head hanging down would take the ground towards the margin and get fastened by its heavy antlers in the stiff clay, and thus would serve to moor or anchor the whole animal in position till putrefaction had caused the integuments of the neck to separate from the body.

During the previous 30 years nearly 100 heads, good and bad, had been found in this small bog, and scarcely six skeletons. The question naturally arose: "What had become of the bones?" One gentleman said that they had been washed down to the centre of the lake, and would be found there. I tried the centre, sinking 13 feet, and all I got was one rib. Another gentleman, more facetious, said that "evidently the animal had the trick of dropping off its head and running away from it." I was greatly puzzled to account for its absence, when one day I remembered that in almost every instance I had found the atlas vertebra imbedded beside the head. It at once occurred to me that, being so firmly attached to the back of the skull, it resisted decay longer; but when the integuments of the neck had sufficiently putrefied, they parted with the strain on them, the axis slipped out of the atlas, it being the least firm point of attachment, and the gas-inflated body floated away, and was carried by the current clean out of the lake to a lower lake or river, or even down to the sea. I believe that this floating theory meets all the requirements and facts of the case.

In the Limerick bogs the skeletons, or some portions of them, are often found with the heads; this is owing to the shallowness and want of current in the lakes in that district; there was not depth enough of water to float away the great carcase with its long legs hanging down. In one instance I found all the legs of one animal with the head: the trunk having apparently floated away.

Surrounding and overlying the remains we find the brown clay (No. 3); it is usually from three to four feet deep, and is, as I have said, a true lake sediment, having a good proportion of vegetable matter interstratified with seams of clay and fine quartz sand, brought down by heavy rainfall from the hills; it seems to represent a genial or temperate climate, such as we have at present. The four feet of deposit seems to represent the time of the reign of the *Megaceros* in Ireland; but this, considering the superficial extent of the bog, must contain hundreds of tons of the clay in question, and may represent a long period. Thus it lived, the climate mild, the soil by this time fertile; it had few, if any, human enemies: if such did exist, they were armed with poor weapons. The Tiger, the Lion, and the Hyæna were absent, for their remains have not been found in this island. The largest predatory animal was the Wolf, which could hardly cope with this great beast. It had extensive prairies to roam over, it multiplied freely, having no drawback except the combativeness of the males at certain seasons, and the chance of getting drowned occasionally in the lakes—by this happy accident insuring for itself a resting-place in museums all over the world.

The growth of the wide-spreading antlers of the animal is worthy of notice. They weigh on an average 60 lbs.; they were of course shed annually, as in other deer; about four months, say 120 days, was occupied in the growth of the new antlers after the fall of the old ones; hence 8 oz., that is, half a pound, of phosphate of lime must have been secreted or deposited by the blood of the animal each day of the period to build up these grand defences; the wonder is how the blood could supply so vast a mass of new material in so brief a space of time.

It has been assumed by some that the animals perished in herds in the lakes; but we have no evidence whatever of this. A number being found together does not prove it. On the contrary, they may have been the accumulation of centuries. The different age of the antlers seems to prove that they died singly. We sometimes find a head with the tracks of the blood-vessels of the antlers as sharp as if it had come out of the "velvet" but yesterday; this individual died about August, just as the antlers were finished. Again I have found beside it antlers well worn and polished, as if it had died in the winter. Again I have found shed-antlers that must have fallen about April. But I never found a skull from which the antlers had fallen because, after dropping them, he may, being so much lighter, have managed to get out of the tenacious lake clay. Female skulls are rarely met with; either they were more timid in swimming lakes, or having no antlers they may have struggled out, or the care of their young prevented their keeping company with the males in the summer season, when they were most likely to get into the lakes to bathe.

Having treated the light brown clay (No. 3) which surrounds and covers up the *Megaceros* remains, we now come to the greyish clay which overlies the latter and underlies the peat. This bed I consider of great importance, as it seems to indicate a change of conditions of deposit and a marked change of climate.

Clay No. 3 appears to be, as I have said, an ordinary lake settlement. The line of separation between it and the overlying bed is pretty sharp and well defined. It was quite usual for the workmen, when the point of their spades touched this clay, to say, "There is the brown;" for we had been taught by experience that the remains of the great deer were not to be expected in the grey clay No. 4. This line of separation is to be found in every part of the bog—it is apparently an *invariable line*. In describing the bog I said it occupied two depressions making originally two small lakes in form like the figure ∞; when we sink in the northern bog or lake, we do not find this bed of clay, but we find its *equivalent*, a bed of gravel, out of which the flow of water washed and carried forward the finer particles and deposited them in the southern lake from year to year over the sediment or brown clay (No. 3), and thus formed the bed No. 4, which is about from 30 inches to 3 feet deep, containing hundreds of tons of nearly *pure argillaceous mineral* matter, such as might be used by the potter. I have said that it indicates a marked change in climate, from mild and genial to one of almost arctic character, when the British Islands in their elevated portions were perhaps covered with perpetual snow, when the Musk-ox, Reindeer, and other Arctic animals ranged down to the south of France, and when our coasts were probably occupied by the Esquimaux or a similar race. It is just such a clay as might be produced by the milky or muddy water that flows from beneath a glacier; but, lest it should be said that I am assuming what is not proved, it may be as well to assign some reasons for my views.

I infer it is a glacial clay, because of its nature and texture. It is purely mineral, or nearly so, and must have been produced from the granitic hills on either side of the valley by the disintegrating action of frost and ice.

I infer it is glacial from its quantity. The bed is nearly three feet thick, spread over about three acres. Why did not this mineral matter come down in like quantity all the time of the deposit of the clay bed No. 3 which underlies it? Simply because during the genial conditions which then existed the hills were everywhere thickly covered with vegetation; when the rain fell, it soaked into the soil, and the clay, being bound together by the roots of the grasses, was not washed down; just as at the present time, when there is hardly any degradation of these hills taking place.

Lastly, I infer ice-action from having in my possession antlers of the *Megaceros* actually scored like a striated boulder. The underside of the antler was firmly embedded in the marl, and has no marks; the upper side was exposed to the grinding action of ice, with coarse sand frozen to its under surface, this miniature glacier must have passed over the antler, and made the scorings in question.

In this glacial bed I found the antler of a Reindeer; what but arctic conditions would have brought this animal so far south?

Nor can I account for the broken state of the *Megaceros* remains, unless from pressure of great masses of ice on the surface of the clays in which they were imbedded, the wide expanse of the palms of the antlers exposing them to pressure and liability to breakage, and even in many instances when there was twelve or fourteen inches in circumference of solid bone almost as hard and sound as ivory it was snapped across. I have been told that a rush of water tumbling the heads over each other, would do this, but it has been stated that the elevation of the valley precluded the possibility of its receiving a river of such force as to produce such effects; moreover the state of the teeth shows the incorrectness of this idea. In every instance

I found the edges of the deer's teeth as sharp as if the animal had died but yesterday; there are no marks of their having been water-worn; hence I conclude that nothing but the pressure of ice will account for the breaking of the *Megaceros* antlers. As a rule, those found near the surface are those most broken; when found deeper down, they are much less so, the thick layer of clay having protected them.

Whether these conditions can be referred to a Glacial period may be questioned; we have no standard to judge by. No doubt it was far less rigorous than the "Great Ice Age"; but it should be remembered that then, as now, the climate of Ireland was not so severe as that of Scotland, England, or the Continent, and if we could make this time synchronous with the period of severe cold on the Continent, or in Scotland, we have evidence sufficient to prove that it might properly be called a glacial period. Whether it caused the extinction of the Megaceros *in Ireland* may be questioned. It is a subject that cannot be proved. All we can do is to arrive at a strong probability. The total absence of human implements or remains in these clays goes far to prove that man had hardly appeared *in Ireland*; hence it is highly improbable that the *Megaceros* was exterminated by man; but when we find that in no instance has it been found in the peat, nor have I ever found it in this glacial clay No. 4, then it becomes highly probable that this bed of clay marks the limit of the existence of the *Megaceros* in Ireland, no doubt by this time insulated, so that it could not have escaped by migration.

Probably a dam existed at the south end of the lake. This was afterwards cut through by ice, thus draining both the lakes. No evidence remains of the dam, except the old water-line several feet higher along the hill-sides. Thus the lake had not only been silted up, but had been naturally drained and afterwards left brim full of alluvium, in fact a swamp, in which *Sphagnum*, *Equisetaceæ* and other marsh plants could grow and lay the foundation of a true peat-bog.

After examining Ballybetagh, I was anxious to explore other bogs, to ascertain if they would tell the same story. The next one visited was Craggah near Balla, Co. Mayo. It is 150 miles from the former place. Here I found perfect accord in the appearance and order of the beds, first the tough bottom clay, in which the animals were mired, the marl bed in which it is found, and the glacial bed just under the peat, just as at Ballybetagh, with this difference, that instead of being greyish, it is a chocolate-brown, as it was derived from the Coal-measures at the upper end of the valley. Seeing this accord in the deposits in places 150 miles apart, I was led to seek for a general cause, and concluded that the cause was not a local one, but due to climatic changes wide in their operation. The next year I visited several bogs in Co. Limerick, with similar results; they confirmed me in my conclusions, that in these deposits we have a reliable record of the changes of climate which have occurred from the times of the deposition of the boulder-clays, and till the peat-bogs began to grow over and cover up the old lake-basins.

As far as I have seen, the reclothing of the country by forest after the denudation of the "Ice age," made little progress till near or after the times of the peat. In the lower deposits of the lake-beds I never found any timber nor met with the *Megaceros* remains. In the glacial beds just under the peat, I have found some branches; but in the peat, as is well known, trees are of common occurrence; nor is it surprising that prairie should precede forest growth by a very long period.[1]

Thus, having traced the silting up of an Irish lake, and the probable changes of climate that an examination of the clays contained therein indicate, we find:—

1st. A cold wet climate, as marked by clay No. 1, which was evidently washed from the hills in the great thaw; it is a pure rain-wash or glacial fluviatile clay.

2nd. A dry and warm period, which succeeded the former, marked by the accumulation of the bed of vegetable matter found in the very bottom of these lakes, during the growth of which the land probably became covered with prairie.

3rd. A mild and genial climate, during which the *Megaceros* appeared in Ireland, leaving the bones of drowned individuals in the lakes, where we find them surrounded and covered up by the brown clay No. 3. The drowning appears to have been caused by the animals having mired or stuck fast in the thick tenacious clay No. 1.

4th. Another glacial period, indicated by the greyish clay described as No. 4, ice-action or frost and thaw bringing it down from the hills, thus filling the lakes, afterwards by the lowering of their level and making the surface of the clays fit for the peat plants to root in. The cold of this period having probably exterminated the *Megaceros* in Ireland.

I believe it will be found that these clays are a key to the changes of climate that have occurred in the northern hemisphere from the great Glacial period up to the times of the peat and forest growths.

2, *Dame Street, Dublin.*

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[1] In a letter to the writer from Dr. James Geikie, F.R.S., F.G.S., of the Geological Survey of Scotland (author of a work entitled "The Great Ice Age," etc., one of our highest authorities on glacial questions), this eminent geologist writes as follows:—"Perth, 1st January, 1880, ... As I told you in former letters, I was not prepared to believe that your marls and peat with *Megaceros* could be older than the last cold phase of the Ice-age. I thought then, and think still, that they are all Post-Glacial—in the sense of being later than the last big ice-sheet. But I think you are right in supposing that cold conditions of climate succeeded to the period when the *Megaceros* lived in Ireland." . . . . "You will see from my paper that your *Megaceros* comes into the 'Age of Forests,' and that the beds immediately overlying the peat will most likely be of the same age as our coarse clays, with Greenland whale, and the latest local, or valley-glaciers—a climate probably approaching to that of Northern Norway."

The writer believes the *Megaceros* lived *before* the forest-period in Ireland, just as it existed previous to the growth of the Peat-bogs.

IV.—The Glaciation of the Shetland Isles.

Reply to Mr. Milne Home's Criticisms in the May Number of the Geol. Mag.

By B. N. Peach, F.R.S.E., F.G.S.; and
John Horne, F.R.S.E., F.G.S.

In the May Number of the Geological Magazine, Mr. Milne Home expresses anew his doubts about our conclusions on the glaciation of Shetland, laying special emphasis on the discordance between the statements of Mr. C. W. Peach and ourselves. He also cites Dr. Hibbert and Mr. Russell as to the position of certain boulders which, he considers, are at variance with our conclusions. In his recent criticisms, Mr. Milne Home still displays a curious misapprehension of many of the facts bearing on this question; besides he has committed a serious error in making allowance for the magnetic variation, on the strength of which he tries to establish a discordance between the trend of the ice-markings as given by Mr. C. W. Peach and ourselves, in Unst and the Outskerries of Whalsay.

We now desire to show (1) that there is no discordance between the *trend* of the ice-markings recorded by Mr. Peach and ourselves in Unst; (2) that the supposed ice-movement from the hills in the north of Unst against "the W.N.W., end" of the Heog Hill, which was advocated by Mr. Peach in 1864, and now abandoned by him, is completely disproved by the direction of the striæ, and more particularly by the dispersal of the stones in the Boulder-clay in that neighbourhood; (3) that there is no discordance between the direction of the striæ recorded by Mr. Peach and some of those noted by ourselves in the Outskerries of Whalsay; (4) that with the exception of the blocks of actinolite schist on Papa Stour, which, according to Hibbert, could only have come from Hillswick, the various erratics cited by Mr. Milne Home may be satisfactorily accounted for by the theory advocated in our paper.

1. In our previous communication, we published a letter from Mr. C. W. Peach, in which he stated explicitly that no allowance had been made for magnetic variation in his observations, which accounted for the discordance so far as the mere trend of the ice-markings is concerned. With reference to this point Mr. Milne Home says, "Messrs. Peach and Horne, commenting on this letter, observe, that when allowance is made for magnetic variation, Mr. Peach's bearings would be not W.N.W. as stated by him, but 'nearly E. and W. as noted by us.' This remark I don't understand; for as the compass in Shetland in the year 1864 stood 24° to the west of true north, Mr. Peach's observations by true bearing indicate N.W., and not due E. and W."

Mr. Milne Home has here committed an error in his calculations amounting to about 46°. The error is perfectly obvious to any one who gives a moment's thought to the subject, but we have made the following calculations to make it transparent at a glance. In 1864 (the year in which Mr. Peach, sen., visited Shetland) the compass in those islands pointed 24½° to the west of *true* north.[1] It follows therefore, that,

Magnetic N. = N. 24½° W. true.
Magnetic N.N.W. = N. 47° W. true, or nearly N.W. true.
Magnetic N.W. = N. 69½° W. true, or W. 20½° N. true.
Magnetic W.N.W. = W. 2° S. true.
Magnetic W. = W. 24½° S. true.

Mr. C. W. Peach recorded striations only from one locality in Unst, viz. on the south side of Haroldswick Bay on the east coast running W.N.W., and E.S.E. (magnetic).[2] From the foregoing table it will be seen that in 1864 W.N.W. magnetic = W. 2° S. true, or nearly E. and W., as noted by us. There is therefore *no discordance between us so far as the mere trend of the ice-markings at that locality is concerned.* The ice which produced these markings must have come from the east or west. Mr. Peach inferred that the movement had been from the west, and this leads us to discuss the evidence he adduced in support of this contention.

2. In addition to the striæ in Haroldswick Bay, the only evidence advanced in his papers, in 1865, was the glaciated appearance presented by "the W.N.W. end" of the Heog Hill, which is thus described. On reaching the top of the Heog Hill (about 500 feet), he found "the W.N.W. end, vertical and polished to the depth of at least 150 feet. The hills to the north of Heog Hill slope down towards it; and down these, no doubt, the crushing agents came. The vertical and storm side of Heog Hill had evidently resisted a portion of the destroyer, and turned the greater part on its western flank, and thus the main body passed down the valley towards Haroldswick, as evinced by the greater destruction there than on the eastern side."

A careful examination of that tract conclusively shows that Mr. Peach was misled by the glaciated appearance of "the W.N.W. end" of the Heog Hill; indeed there can be little doubt that if he had found time to examine the ground minutely, he would have had no occasion now to regret "the oversight and neglect of the warnings of Hammer and Watlea" referred to in his letter. A slight knowledge of the geological structure of the ground enables us to explain the origin of the steep rock slope described by Mr. Peach. From the south shore of Haroldswick Bay westwards to the Loch of Cliff and Baliasta there is a ridge of hilly ground composed of serpentine about two miles in length. The Crusafield Hill forms the western termination of the ridge near the Loch of Cliff, while the Muckle and Little Heog Hills are situated near Haroldswick Bay. On the west, north-west, and north sides there is a steep declivity, but to the east and south-east, the gradient is gentle. The boundary-line between the serpentine and soft schists lying to the north and west runs from Norwick Bay on the east coast to Baliasta, skirting the north-west and west slopes of this hilly ground. This boundary-

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[1] The true direction was 24° 35′, which is, roughly speaking, 24½°. This applies to the middle of the group. Northwards from this there was a slight increase and southwards a decrease in a regular ratio.

[2] See Geol. Mag. 1865, p. 343.

line is coincident with a well-marked hollow, which is due to the fact that the soft schists which dip beneath the serpentine have succumbed more readily to the denuding agencies, thus causing the serpentine to weather backwards as a steep escarpment. In short, the steep rock slope dates from Pre-glacial times. Further, the whole of that steep declivity is glaciated, but not more so than the east or south-east slopes or the tops of the hills. The whole ridge is *moutonnée,* and after careful searching the only striations noted by us occur on the east and south-east slopes pointing W. 8°–10° S., nearly parallel with the long axis of the ridge. Mr. Peach inferred that the ice moved southwards from the hills lying to the north of the Heogs, evidently referring to the hills round Saxavord, till it abutted against the steep rock slope and was deflected eastwards into Haroldswick Bay. But such a supposition does not explain the glaciated appearance of the tops of the Heogs or the striæ running parallel with the ridge on the south-east slope. Moreover, it is directly disproved by the trend of the striæ on the eastern sea-board north of Haroldswick Bay. On the cliff top of the Nivv Hill, at a height of 500 feet by aneroid measurement, we found striæ pointing W. 10° S. which, it may be observed, are identical with those on the south-east slope of the Heogs. Again, near the village of Norwick the trend is W. 20° S. Both of these localities are situated immediately to the east of the line of the supposed movement from the hills lying to the north of the Heogs. We shall point out presently, that the westerly movement indicated by the striæ on the Nivv Hill and at Norwick is placed beyond doubt by the dispersal of the stones in the Boulder-clay; but we will now quote the various examples of striated surfaces noted by us in Unst in order to show that they clearly indicate a uniform and persistent movement across the island in a W. and W.S.W. direction.

W. 20° S.	On shore near Norwick Old Church, near Norwick Bay.	
W. 20° S.	On extreme south-east point inclosing Norwick Bay—East coast.	
W. 10° S.	On shore, top of cliff 500 feet high, Nivv Hill	,, ,,
W.[1]	North shore of Haroldswick Bay.	,, ,,
W.	Haroldswick Bay.	,, ,,
W. 10° S.	On shore, top of cliff, north side of Swina Ness.	,, ,,
W. 10° S.	On shore, south side of Swina Ness.	,, ,,
W. 10° S.	Near previous locality.	,, ,,
W. 8° S.	East slope of the Heogs.	
W. 10° S.	South-east slope of the Heogs, above road leading to Hagdale.	
W. 10° S.	In burn near Buness House, Balta Sound.	
W. 10° S.	On shore near Hammer, Balta Sound.	East coast.
W. 5° N.	On shore at south entrance of Balta Sound.	,, ,,
W. 20° S.	On shore opposite Balta Sound.	,, ,,
W. 12° S.	On shore opposite north end of Huna Island.	,, ,,
W.	On shore opposite south end of Huna Island.	,, ,,
W. 6° S.	East slope of Vord Hill.	
W. 20° S.	On shore north of old Castle of Muness.	East coast.
S. 42° W. W. 4° S.	Cross-hatches, on shore east of Muness hamlet, south-east promontory of Unst.	

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[1] As there was a strong local deflection of the compass amounting to about 25° at this point, the proper direction of these striations was obtained from a party of the Ordnance Survey, who were at work near the spot at the time they were noted.

W. 10° S.	A few yards south of previous instance.	
W. 30° S.	On shore near Lund, north of Belmont.	South coast.
W. 30° S.	At Houlon Ness.	West coast.
W.N.W.	Near Collaster.	,, ,,

From this list it is apparent that the ice-markings must have been produced by ice moving in a determinate direction along a W. and W.S.W. line. There is only one exception, at Collaster, which harmonizes with the north-westerly trend on the west side of Yell and the Mainland. Indeed, when we consider that the striæ occurring at a height of 500 feet agree with those found on hill slopes and at the sea-level, it is impossible to escape the conclusion that the agent which produced them must have pressed uniformly on hill and valley, along the lines indicated by the striæ.

But the supposed ice-movement from the hills round Saxavord against "the W.N.W. end" of the Heog Hill is also disproved by the dispersal of the stones in the Boulder-clay. On the west side of the Saxavord Hill, overlooking Burra Fiord, a deposit of Boulder-clay occurs at a height of 300 feet above the sea. The deposit is about fifty feet thick. A considerable proportion of the included stones consists of the characteristic hornblendic granite of Lambaness and Scaw, about two miles to the east of Saxavord Hill. This rock is easily recognized on account of its porphyritic character; the pink felspar crystals measuring upwards of two inches in length. In our paper we pointed out that "ere these granite fragments could have reached this position along the path line indicated by the striæ, they must have been transported in the *moraine profonde* across the shoulder of Saxavord Hill, where it attains a height of 600 feet; whereas none of the Lambaness granite occurs *in situ* at a greater height than 150 feet."

Moreover, it was clearly pointed out in our paper that a careful examination of the stones in the Boulder-clay on the west coast proves beyond all possibility of doubt that the ice must have crossed Unst from the North Sea to the Atlantic. Between Woodwick and Wick Bay striated blocks of gabbro and serpentine occur in this deposit, which have been carried across the intervening water-shed nearly 700 feet high. We showed that the relative distribution of the gabbro and serpentine stones in this deposit on the west coast is in direct proportion to the respective areas occupied by these rocks on the east side of the water-shed. The occurrence of these blocks in the sections referred to cannot be disputed. Indeed, our observations have been confirmed by Prof. Helland, of Christiania, who arrived at similar conclusions regarding the westerly movement of the ice in Unst.[1] Mr. Peach's traverses did not extend to the west coast, but he noted the occurrence of striated serpentine stones in the Boulder-clay at Loch Watlea, to the *west* of the serpentine area.[2] There is little wonder that this fact puzzled him very much at the time, considering the hypothesis he adopted after a rapid examination of only a portion of the island. It is physically

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[1] Zeitschrift der Deutschen geologischen Gesellschaft, Jahrgang 1879, p. 716.

[2] Geol. Mag. Feb. 1881, p. 67.

impossible that ice coming *from* the north or west could transport blocks of porphyritic granite in the Boulder-clay, from the north-eastern headlands of Unst to the west slope of Saxavord Hill, or striated stones of serpentine and gabbro to the west of the areas occupied by these rocks. When the foregoing facts were laid before Mr. C. W. Peach, in the summer of 1878, he readily perceived the conclusive nature of the evidence regarding the westerly flow of the ice in Unst, and he frankly admitted that he had been misled by the glaciated appearance of "the W.N.W. end" of the Heog Hill. In the words of his recent letter, though he noticed the bearings of the striæ right, he was wrong as to the direction of the drift.

3. Mr. Milne Home further says: "Unst, however, is not the only island where a discordance exists between Mr. Peach's observations of the striæ and those of Messrs. Peach and Horne. Mr. Peach, senior, examined Whalsay, a small island situated a few miles to the east of the Mainland, and therefore one of the first spots which would be passed over by the alleged Scandinavian Ice-sheet. Messrs. Peach and Horne say of this island that, on both sides of it, there are striations, showing an average movement towards S. 28° W. On the other hand, Mr. Peach, senior, says that, not satisfied with taking the direction of the striæ at places where he found the rocks exposed, he removed the drifted clay and stones, in order to obtain a fresh surface; and the scratches at all the places (he says) 'run nearly east and west,'—which, by true bearings, would be E.S.E. and W.N.W. Here, again, is discordance between Mr. Peach, senior, and the authors of the paper."

This passage is an example of the curious misapprehension of the facts, of which we complain. The alleged discordance is utterly groundless. Mr. Milne Home here confounds Whalsay with the Outskerries of Whalsay, which lie about five miles to the E.N.E. of that island. In point of fact, Mr. Peach, senior, never examined the glacial phenomena of Whalsay at all, but he visited the Outskerries. Besides, Mr. Milne Home makes another serious error, amounting to about 46°, in making allowance for the magnetic variation. Mr. Peach states in his paper that he found striæ only at two localities in the Outskerries, which "ran E. and W."[1] (magnetic). By referring to the table on a preceding page, it will be seen that *in* 1864 *E. and W. magnetic* = *E.* 24½° *N. and W.* 24½° *S.*

In the course of our visit to the Outskerries, we noted 19 instances of striations, which we summarized in our paper as follows: "In Gruna the striæ vary from S. 10° W. to W. 42° S.; in Brury, on the top of the highest hill, S. 35° W., and in Housay S.S.W. to S.W." Instead of quoting the various examples, it will be sufficient for our present purpose if we refer to some on Gruna, opposite the lighthouse. In the Bay, east of the lighthouse keepers' dwelling-houses, we observed several examples of ice-markings pointing W. 25° S. The difference, therefore, between the true bearings of the striations recorded by Mr. Peach and those we noted on the east side of Gruna amounts to ½°. Any one accustomed to map glacial striæ

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[1] Geol. Mag. 1865, p. 342.

can easily understand how, in a group of scattered islets, the direction may vary from W.S.W. to S.W. and S.S.W., according to local deflections.

Mr. Milne Home questions the possibility of local glaciers giving rise to the south-easterly striæ on the east coast of the Mainland between Lerwick and Dunrossness. When we consider the high northern latitude, and the severe Arctic conditions which then prevailed, there is nothing improbable in the supposition that local glaciers existed in that long tongue of land where the hills range from 500 ft. to 800 ft. in height. The moraine heaps and morainic deposits which are so plentifully developed in Shetland as surely point to the existence of local glaciers as the large mounds in our Highland glens and in the upland valleys of the South of Scotland.

In his concluding remarks regarding the striæ on the eastern seaboard of Shetland, Mr. Milne Home states, "that so far from confirming the theory of an invasion of an Ice-sheet from the N.E., most of these striæ are at right angles to that direction." To this we reply that out of 197 instances of ice-markings recorded by us in Unst, Yell, Fetlar, Whalsay, the Outskerries of Whalsay and the eastern seaboard of the Mainland, 159 point W., W.S.W. to S.S.W., while 38 point in a south-easterly direction.

Mr. Milne Home takes exception to our statement that the ice-sheet when it reached the crest of the Mainland veered round to the N.W. so as to follow the path of least resistance, and from the tenor of his remarks he has evidently misunderstood our argument. To quote from his paper, "Now this huge mass, it is said, when it impinged on the Shetlands, and reached the crest of the Mainland, 'was deflected by the opposing high ground,' and in order to 'follow the path of least resistance,' swung round to the N.W. The Shetlands form a group whose axis is N. by E. and S. by W. If it be possible to imagine, that a body of ice of the above gigantic dimensions, bearing down on these Islands from the N.E., could have its course changed by impinging on them, so as to seek the path of least resistance, its progress would have been along the Eastern Seaboard of the Islands in a direction S. by W., and not across the backbone of the Islands in a N.W. direction."

We endeavoured to show that the ice-sheet was deflected by the opposing high ground *before* it reached the crest of the Mainland. In fact, the deflection along the eastern seaboard, suggested by Mr. Milne Home in the foregoing passage, is what we believe to have been the case. The ice-sheet as it impinged on the Shetland frontier was deflected towards the S.W. and S.S.W. by the backbone of the group, but eventually the pressure of the advancing mass was sufficient to compel it to override even the highest hills, and on reaching the crest of the Mainland, having surmounted the resisting high ground, it naturally veered round to the west. Our recent work in Orkney, however, enables us to account for much of this northing along the western seaboard of Shetland. The Orcadian group was glaciated by Scotch ice moving in a north-west direction, and the latter ice-sheet must have had a considerable influence in deflecting the Scandinavian *mer de glace* to the N.W. on the west side of Shetland.[1]

Mr. Milne Home next proceeds to inquire whether the striæ support this movement towards the N.W. on the western seaboard. Again, we must be excused for calling attention to his misapprehension of the facts. The various examples quoted by him do not bear on this question at all, as they occur on the *eastern seaboard* of Northmavine on the Mainland. Northmavine is not one of the westerly islands, but the northern parish of the Mainland, and by referring to page 792 of our paper, it will be seen that all the instances qnoted by him (Geol. Mag. p. 209) are clearly described as occurring on *the eastern seaboard* of Northmavine in the Mainland.[2]

4. The various boulders cited by Mr. Milne Home may be satisfactorily explained by the theory advocated in our paper, save the blocks of actinolite schist on Papa Stour, which, according to Hibbert, could only have come from Hillswick Ness. Mr. Milne Home asks why we omitted to take notice of the boulders recorded by Hibbert, and the answer is simply this : that in the summary of our work which appeared in the Quart. Journ. of the Geol. Soc. we confined ourselves exclusively to our own observations on the glacial phenomena. The original MS. contained a detailed reference to Dr. Hibbert's paper "On the Direction of the Diluvial Wave in the Shetland Isles."[3] In our published paper we merely stated the conclusion which he came to, viz. "that the great diluvial wave which swept over the low elevations of the whole of Scotland and England had in the latitude of Shetland a north-easterly origin, or in other words, a south-westerly direction."[4] It is somewhat remarkable that Hibbert should have arrived at this conclusion 50 years ago, merely from an examination of the boulders lying on the surface. He paid no attention to the ice-markings or the dispersal of the stones in the Boulder-clay. No one could allege that he was prepossessed in favour of the theory that Shetland was glaciated by Scandinavian ice. And yet, almost all the boulders described in his paper confirm our conclusions as to the direction of the ice-movement during the primary glaciation!

Following the order in Hibbert's paper, the blocks of actinolite schist on Papa Stour fall to be discussed first. Though we examined every mile of the coast-line, and crossed the island, we did not light on these blocks, but we have not the slightest doubt that they are to be found. Hillswick Ness, from which these blocks were transported according to Hibbert, lies about 12 miles to the north-east

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[1] Quart. Journ. Geol. Soc. vol. xxxvi. p. 648.

[2] Mr. Milne Home seems to consider the separate movements of the upper and lower portions of the ice-sheet as indicated by the striæ near Fethaland Point, an "extraordinary physical phenomenon." Evidence of a similar double movement has been observed by Professor Ramsay among the Yorkshire hills, and Professor Hull has described another example in connexion with the Lough Erne Valley. See "Physical Geology and Geography of Ireland," by Prof. Hull, p. 239; also see "Great Ice Age," 2nd ed. p. 290.

[3] Edin. Journ. Science, vol. iv. p. 88.

[4] Q. J. G. S. vol. xxxv. p. 779.

across the Bay of St. Magnus. This direction is at variance with all the striæ we noted on the island which are given in the following list:—

N.W. on east side of Culla Voe—Head of the Voe.
N. near head of Culla Voe.
N. 6° W. west bank of Culla Voe.
N. 20° W. east side of Culla Voe.
N. 20° W. ditto ditto.
N. 20° W. on headland mouth of Culla Voe.
N. 20° W. }
N. 20° W. } three localities at mouth of Olas Voe.
N. 20° W. }
N. 28° W. west bank of Olas Voe.
N. 20° W. on promontory about one mile east of Hamma Voe.
N. 4° E. near previous instance.
N. 3° W. on shore west of Bay, south of church.

In the Boulder-clay on Papa Stour, numerous striated blocks of the altered Old Red rocks are to be found, which were derived from the area occupied by these rocks between Sandness and Bixetter Voe; thus clearly indicating that the ice which produced the striæ must have come from the south-east. We think it is highly probable therefore that, in a region where the rocks are so highly metamorphosed, bands of actinolite schist may be met with along the track of the Scandinavian *mer de glace* as indicated by the striæ. We noticed various blocks of hornblendic schist, of gneiss, and mica schist on the island brought thither from the centre of the Mainland. But even though these blocks of actinolite schist came from Hillswick Ness, it would not invalidate the evidence in favour of the primary glaciation. It would only point to a later movement at right angles to the great extension of the ice. By referring to the map accompanying our paper, it will be seen that we have noted striæ in the neighbourhood of Walls and Sandsting pointing towards the S.W., at right angles to the older set. Where the surface is "cross-hatched," the latter have been well-nigh effaced by the later glaciation. By means of this later movement the altered Old Red rocks were borne south-westwards on to the area occupied by the Sandness granite.

Dr. Hibbert next refers to the Stones of the Stefis, near the mansion of Lunna, on the eastern sea-board of the Mainland, which have been transported a mile or two in a south-westerly direction from their parent source. Thereafter he notes the occurrence of large fragments of serpentine and euphotide on the east coast of Yell, which have been carried from the islands of Unst and Fetlar, lying to the east. These examples confirm our own observations regarding the south-westerly movement on the eastern sea-board during the primary glaciation. The blocks of primary greenstone (diabase) on Roeness Hill, which he says have been rolled in a southerly or south-westerly direction up a gradual ascent of three or four miles, entirely support our conclusions. These boulders, in our opinion, were carried uphill by the Scandinavian *mer de glace* in a south-west direction along the lines indicated by the striæ on the eastern seaboard of Northmavine. The boulder on Hillswick

Ness is composed of granite, which, according to Hibbert, was "removed from a rock, the nearest site of which is about two miles to the north." But this boulder might quite well have been derived from some of the bosses of the same material lying at a slightly greater distance to the east and north-east of Hillswick.

Mr. Milne Home also cites the "return" sent in by Mr. Russell to the Edinburgh Royal Society Boulder Committee regarding seven boulders of granite and gneiss in Foula. Mr. Russell suggests that these have been transported from Culswick and Delting lying to the north-east. He adds that from the middle of the island, at a height of 700 feet, granite and gneiss drift occurs as far as the south end of the island. Quoting from the statistical account of Scotland, Mr. Milne Home says the island is composed of Old Red Sandstone. He is evidently not aware of the fact that the eastern part of the island consists of gneissose rocks with a mass of granite in the north-east corner. We believe that Dr. Gibson was the first to point out that the Old Red Sandstone of Foula was thrown against the crystalline rocks by a north and south fault[1]—an observation which we confirmed. The granite mass resembles the rock in Sandsting, so that the boulders may have been of local origin, and we noted several blocks of gneiss of local origin. We also observed that the metamorphic rocks were borne towards the W.N.W. and N.W. on to the Red Sandstone area, and in the Boulder-clay west of the fault we detected a block of epidotic syenite from Dunrossness. The later glaciers shed from the hills carried some Old Red débris on to the area occupied by the gneiss. A fine series of moraines with the usual concentric arrangement occurs in the valley draining the north end of the island.[2]

Mr. Milne Home asks, how the occurrence of boulders perched on ridges and hill tops can be explained on the supposition of a great *mer de glace*, which overrode the whole islands and smothered them in ice. To this we reply that some of the boulders were borne forwards in the ground moraine, while others became fixed in the lower portions of the ice-sheet, and were likewise carried along by the advancing mass. As the ice melted backwards, the blocks and angular débris were stranded at the localities where we now find them, except where they were displaced by later movements.

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[1] Brit. Assoc. Reports for 1876, p. 90. Dr. Gibson states that no fossils had been found in the Old Red Sandstone rocks of Foula. We were fortunate enough to discover numerous specimens of *Psilophyton princeps*, Dawson, in shales in the north of the island. Similar plant-remains occur in the sandstone near Lerwick and Sandlodge, on the east side of Shetland.

[2] Had we been disposed to refer to the observations of others, which were not corroborated by ourselves, we might have adduced the testimony of Mr. Milne Home, regarding Norwegian boulders in Shetland. In an article entitled "Are there no boulders in Orkney and Shetland?" Nature, vol. xvi. p. 476, he refers to certain boulders reported to the Edin. Roy. Soc. Boulder Committee. Under the heading "Bressay" the following statement is made: "A number of boulders here, of a rock foreign to the island. One of them is 10 × 7 × 4 feet. Supposed to have been transported from Norway."

NOTICES OF MEMOIRS.

I.—On the Existence of the Mastodon in Recent Times in North America.

In his Report for 1880, Prof. John Collett, Ph.D., State Geologist of Indiana, says:—Of the thirty individual specimens of the remains of the Mastodon (*Mastodon giganteus*) found in this State, in almost every case a very considerable part of the skeleton of each animal proved to be in a greater or less condition of decay. The remains have always been discovered in marshes, ponds, or other miry places, indicating, at once, the cause of the death of the animal and the reason of the preservation of the bones from decay. Spots of ground in this condition are found at the summit of the glacial drift or in "old beds" of rivers which have adopted a shorter route and lower level, consequently their date does not reach beyond the most recent changes of the earth's surface; in fact, their existence was so late that the only query is, Why did they become extinct? A skeleton was discovered in excavating the bed of the canal a few miles north of Covington, Fountain County, in wet peat. The teeth were in good preservation, and Mr. Perrin Kent states that when the larger bones were cut open the marrow, still preserved, was utilized by the bog cutters to "grease" their boots, and that chunks of sperm-like substance, 2½in. to 3in. in diameter (adipocere), occupied the place of the kidney fat of the monster. During the past summer of 1880, an almost complete skeleton of a Mastodon was found six miles north-west from Hoopston, Iroquois County, Ill., which goes far to settle definitely that it was not only a recent animal, but that it survived until the life and vegetation of to-day prevailed. The tusks formed each a full quarter of a circle, were 9ft. long, 22in. in circumference at the base, and in their water-soaked condition weighed 175 pounds. The lower jaw was well preserved with a full set of magnificent teeth, and is nearly 3ft. long. The teeth, as usual, were thickly enamelled, and weighed each from four to five pounds. The leg bones, when joined at the knee, made a total length of 5½ft., indicating that the animal was not less than 11ft. high, and from 15 to 16ft. from brow to rump. On inspecting the remains closely, a mass of fibrous, bark-like material was found between the ribs, filling the place of the animal's stomach; when carefully separated, it proved to be a crushed mass of herbs and grasses, similar to those which still grow in the vicinity. In the same bed of miry clay a multitude of small freshwater and land shells were observed and collected, which were kindly determined by Dr. F. Stein, as follows:—1. *Pisidium*, closely resembling *P. abditum*, Haldeman. 2. *Valvata tricarinata*, Say. 3. *Valvata* resembling *V. striata*. 4. *Planorbis parvus*, Say. The shell-bearing animals prevail all over the States of Illinois, Indiana, and parts of Michigan, and show conclusively that, however other conditions may differ, the animal and vegetable life, and consequently climate, are the same now as when this *Mastodon* sank in his grave of mire and clay.—*English Mechanic*, No. 847, June 17, 1881.

II.—ON THE CLASSIFICATION AND THE CHRONOLOGY OF THE TERTIARY ERUPTIVE ROCKS OF HUNGARY. By Prof. M. SZABO.

(Extracted from the "Compte rendu sténographique du Congrès internationale de Géologie," held in Paris, Aug. 29–31 and Sept. 2–4, 1878.) Imp. Nat. 1880.[1]

TO contribute to the solution of the great problem raised by the study of the eruptive rocks, I have devoted myself to the lithological and geological examination of the trachytic district of Hungary.

The first question to be solved was this: Is there a certain relation between the mineralogical constitution and the relative age of the different trachytic types?

To determine these types, I have taken as a starting-point the mineralogical association which they present, and since among their constituent elements the felspars play a predominant part, I have, in the first instance, endeavoured to establish a prompt and easy method for the determination of the different species of this group in rocks.

One of the first results of these investigations has been to show that instead of the ten series of felspars established by Tschermack, one may be contented, so far as the trachytes are concerned, with the four principal species generally recognized by the French school.

One may then distinguish in these rocks four principal types each characterized by the nature of its predominant felspathic element, viz.:—*anorthite-trachyte, labrador-trachyte, oligoclase-trachyte,* and *orthose-trachyte.*[2]

To define these different types, however, more precisely, it is needful to add to the designation of the felspar an enumeration of the principal minerals which are associated with it in each of the rocks. Thus we have:—

1. *Anorthite-pyroxene-trachyte,* characterized also by the absence of black mica and quartz; amphibole is not excluded.
2. *Labrador-mica-trachyte,* with amphibole, with or without quartz, with or without pyroxene, and with or without garnets; in this rock the amphibole plays a dominant part.
3. *Oligoclase-mica-amphibole-trachyte.* In this type the amphibole decreases in amount, but quartz is never absent.
4. *Orthose-mica-trachyte,* always accompanied by a triclinic felspar (generally oligoclase). Quartz is never wanting, but amphibole is often absent. These different types are not fixed; transitions occur between them, resulting from the mixture of the felspathic species of which it is needful to take account in a more detailed description.

To appreciate the value of this classification, let us consider the relative age of the Hungarian trachytes. All geologists agree in recognizing that the phase of greatest activity in trachytic eruptions is met with in the Middle and Upper Miocene, and it is therefore possible to determine the age of the various types of these rocks in the breccias and tuffs containing characteristic fossils.

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[1] Translated by Frank Rutley, F.G.S.

[2] The term orthose includes orthoclase and sanidine.

I have always noticed that the micaceous labrador-trachytes occur in the breccias containing fossils of the Middle Miocene (Mediterranean stage) ; the oligoclase-trachytes and the orthose-trachytes are also met with sometimes on this horizon, but never those of the anorthite-pyroxene type. This indicates that the latter types of trachyte are of later date. The trachytic tuff containing fossils of the Upper Miocene (étage Sarmatien) consists chiefly of anorthite-trachytes, but trachytes of the other types may also be recognized in it, and we may therefore conclude that this anorthite-trachyte is more recent than that containing labradorite. In order to learn the age of the oligoclase-trachytes and orthose-trachytes I have examined the oldest tuffs; and this question is now limited by reason of the discovery of trachytic fragments in the Upper Eocene deposits of Budapest, associated with the Nummulites and the other Foraminifera characteristic of this formation (étage) ; these trachytic fragments are orthose-trachyte. In the district of Gran, in a higher horizon, which, however, still belongs to the Upper Eocene, one meets with sheets of oligoclase-trachyte, two or three mètres in thickness, without the least trace of labrador-trachyte or of anorthite-trachyte.

The orthose-trachytes and the oligoclase-trachytes are, therefore, the oldest rocks of this eruptive series, while the anorthite-trachyte is demonstrably the most recent. As an additional proof of this it may be stated that the anorthite-trachyte traverses all the other types, but is itself cut by none of them.

These observations lead to the following important conclusions :—

1. Contact phenomena exist, and at the limit of two different types, there is sometimes a mixture of the minerals belonging to the two adjacent types.

2. The different types have undergone important modifications, which deserve special designations. It, therefore, becomes necessary to recognise a normal and a modified condition for each trachytic type; while the older the type, the more it is modified. The anorthite-trachyte is the one which most frequently occurs in a normal condition.

The principal modifications are known by the following names: *rhyolite, lithoidite, trachytic-greenstone, domite, millstone-porphyry, alunite.*

Rhyolite, accepting the term strictly in the sense in which it has been proposed by Richthofen, comprises obsidian, perlite, pitchstone, and pumice; it is formed last, during the eruption of one of the most recent types by the intervention of very fusible hydrated silicates, and it is these hydrosilicates which for the most part give rise to fluxion structure.

The presence of the rhyolitic modification is then an important character for determining relative age, for it always leaves the supposition of the existence of a more basic trachyte.

Of all the types the orthose-trachyte affords the most perfect rhyolites, the oligoclase-trachyte much less so, while the labrador-trachyte never forms either obsidian or pitchstone, but it becomes feebly perlitic and pumiceous. The anorthite-trachyte becomes merely pumiceous, and assumes an appearance which Beudant has designated *semi-vitreous*. It is also often possible to follow the transition from the normal to the rhyolitic condition; the amphibole and augite being the first to disappear, since they are the minerals which fuse most easily.

Of all the felspars, orthose is the most remarkable for possessing the power of undergoing hydration. This it does more easily than the soda and lime felspars; so that, in the obsidians, pitchstones, and porphyritic perlites, where we find quartz, mica, and felspar, the last is always oligoclase, while the potash is met with in the vitreous mass.

Lithoidite is the product of devitrification of the rhyolites. *Trachytic-greenstone* has a different composition, and varieties of it occur, just as the normal trachytes vary. It is possible to follow very clearly the natural transition from the normal condition of trachyte to that of greenstone. This transition results from subsequent solfataric action. The sulphurous and metallic emanations have impregnated a certain region of trachyte of one or another type, producing in it a series of changes which are still going on. The matter resulting from these changes has given rise to the formation of metalliferous lodes. The name *trachytic-greenstone* is useful and even necessary for the miner, but, for the geologist, it has no existence as a special formation; a *propylitic* eruption has never taken place.

Domite is a modification of an old type, caused by the volcanic action of a later eruption, especially by the emanations of hydrochloric acid which have removed the iron from the magnetite and the ferruginous minerals, but which has not altered the felspar, which in domite is always glassy.

Millstone-porphyry is a siliceous modification of an earlier trachytic type, which occurs either in a massive condition, or in the form of breccias or conglomerates. The millstone-porphyry of Sarospatak of Beudant, containing well-preserved sanidine and doubly-terminated pyramids of quartz, is simply breccia containing Middle Miocene fossils.

Alunite is the modification caused by emanations containing sulphuric acid, which decomposes the felspathic silicates. One always finds in the alunites masses of quartz, millstone-quartz (Silex-meulière), and if there has been a persistent disengagement of sulphuric acid, the vapour of water has carried off the alkaline sulphates, and the sulphuric acid has combined with the alumina. In this way the kaolin, which always accompanies alunite, has been formed. I have found silicified wood in the alunite deposits of Beregszaz, and the remains of Upper Miocene Molluscs at Sarospatak.

Regarding the trachytic formation as a whole, it should be considered as an eruptive unit, and may be termed a *cycle of eruption*. I am convinced that the trachytes of Hungary, those of Servia, which are but a continuation of them, as well as those of the Enganeen Hills in Italy, belong to the same cycle. They are contemporaneous, and correspond with one another. This probably does not hold good for the trachytes of Auvergne, and for those of the Grecian Islands, where much more recent cycles of eruption have occurred.

These cycles of eruption may also be followed back into earlier times, into the Secondary epoch, or into the Palæozoic ages, and I have already satisfied myself that the series of felspathic rocks at different periods is often the same.

The basalt of Hungary seems to be an episode of the great trachytic formation, derived from a lower horizon, but nevertheless related to the trachytes. In Hungary the basaltic eruption has terminated the volcanic action, during and even after the deposition of the *couches à congéries* (Pliocene).

The anorthite-trachyte forms more than 50 per cent. of the trachytic mass; the labrador-trachyte 30 per cent., the oligoclase-trachyte 15 per cent., and lastly the orthose-trachyte 5 per cent. The first of these is, therefore, the most important, inasmuch as it still forms the highest trachytic mountains of the district (sometimes with an elevation of over 6000 feet); moreover we may for the most part attribute to it those secondary actions which have modified the other types.

REVIEWS.

I.—NOTE-BOOK OF AN AMATEUR GEOLOGIST. By JOHN EDWARD LEE. pp. 90; 209 Plates. (London: Longmans, Green, & Co., 1881.)

WE must confess to some disappointment in turning over the pages of this work, but our disappointment is caused by what is generally considered to be a fault on the right side, inasmuch as the author in his text has given us far too little of his personal experiences. Few men have seen more than Mr. Lee of sections and districts that have been rendered famous by the descriptions given of them by our leading geologists; and if he has for the most part followed in the footsteps of others, he has himself rendered good service to science by the magnificent collections he has made. In his museum are included not a few specimens new to science, and many others personally obtained, which have enlarged our knowledge of the fossil fauna and flora of particular districts. Some of them are shown in the plates now before us. Nor can we contemplate the illustrations which form the bulk of this work, without a feeling of reverence, taking us back as they do fifty years or more, when the study of geology was cultivated by the few, mostly men of means and position.

The author speaks with affectionate regard of John Phillips, to whom he owed his earliest geological lessons, and in whose company he spent many of the happiest hours of his life. In the preface to his work on the Palæozoic Fossils of Cornwall, Devon, and West Somerset (1841), Professor Phillips acknowledges the assistance he had received from Mr. Lee, who had at that time laboured very successfully among the Devonian rocks. In previous years the two friends had been fellow-labourers on the geology of the North of England. Mr. Lee attended the first meeting of the British Association at York, and in 1837 published conjointly with Mr. W. H. Dikes, F.G.S., a paper on the Geology of Nettleton Hill, in Lincolnshire (Mag. Nat. Hist. Nov. 1837). A model of the district was also made, and a plaster-cast of it sent to the Geological Society of London.[1] Mr. Lee reprints this paper, which is illustrated by two plates.

The present work, which is really a "retrospect of a life's work in geology," is chiefly made up of lithographs of sketches from the author's note-book, commencing in 1829, and carried on with some breaks to 1880. These are accompanied by descriptive notes, for the most part brief, and a number of woodcuts. The illustrations being placed in chronological order, there is naturally no system. The majority of them are diagrammatic sections, some are pictorial; but not a few appear too meagre to deserve a place in the collection, being no doubt of personal interest to the author, and such as might be drawn on a black-board to illustrate a lecture, but which, taken with the brief descriptions given, do not convey sufficient information to justify their publication. Plate xxxi. Raised beach, near Hope's Nose, might, with a little more detail in the drawing, have been made a more instructive diagram: while Plate xxxiv. showing joints in the Exeter (New Red) Conglomerate is rather perplexing for want of more natural delineation. Plate xii. Junction of the Lias and Old Red, near Liswerry, includes representatives of the Rhætic Beds (undistinguished, it is true, when the section was made in 1854), but their indication would have been useful to the student. The junction is said to be of Lias and Old Red Sandstone —but are not the lowest beds marked "Red Marl" the Keuper?

Plate lv. Slannie Quarry, north of St. Fagans, marked "Lias on Permian," shows no New Red rocks, nor have Permian strata been determined in the area. Plate cxx. "Contortions in Drift, etc., near Old High," should, we presume, be Old Hithe, between Runton and Weybourn.

Mr. Lee introduces us to many sections in Scotland. There is a good diagram of Ardtun Head, Mull (Plate xlvi.)—a spot which is not very easy of access, for, as Mr. Lee remarks, "We had, in the first place, to cross the whole of the island of Mull in a fierce rain, and slept at Bunessan. Early the next morning the walk from this place to Ardtun Head was anything but pleasant, from the immense quantity of water which had fallen and thoroughly soaked the moorland district. . . . The only way of examining the section was by descending a sort of crack or chink, which was not particularly agreeable, with the roaring waves in sight below, but, nevertheless, it was accomplished, and amply repaid the trouble and risk." Other sections in Ireland are described, and Mr. Lee takes us to many instructive geological localities on the continent.

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[1] These are referred to in Prof. Judd's paper on the Lincolnshire Wolds, Quart. Journ. Geol. Soc. vol. xxiii. p. 228.

We ought to do Mr. Lee the justice to mention that in publishing his sketches, his sole object has been to record facts. He says, "there is not a single theoretical diagram amongst them," each sketch represents what was actually seen, and hence they lack the clearness of many published sections which represent the continuation of strata too often concealed, or in other words, what ought to have been seen; though we must not forget that many published longitudinal sections simply give the explanations or opinions of the expounder. Under such circumstances, Mr. Lee's efforts are praiseworthy, while open to the objection of not always being sufficiently explicit.

At p. 87 Mr. J. E. Lee acknowledges the assistance of Mr. C. Spence Bate, F.R.S., who has contributed notes upon two crustaceans forming the subjects of plates cciv. and ccv. It is rather unfortunate for Mr. Lee that his friend seems to have been unacquainted with this well-known fossil crustacean (pl. cciv.) so abundant in the Lower Greensand of Atherfield, Isle of Wight, figured in Bell's Fossil Crustacea, Pal. Soc. Mon. 1862, pt. 2, p. 32, pl. x. as *Meyeria vectensis;* but which Mr. Spence Bate erroneously names *Mecochirus Pearcei,* M'Coy,—a minute Oxford Clay Crustacean from Wiltshire with which this Greensand fossil has nothing to do.

To criticize the work in a severely scientific point of view has not however been our object. In turning over its pages we cannot refrain from heartily sympathizing with the author: for we feel assured that geology is largely indebted to him and others whose genial enthusiasm in science acts as a spur and encouragement to young geologists, and may be an example to those more advanced in years.

II.—Journal of the Royal Microscopical Society. Ser. 2, Vol. I. Part 3, June, 1881.

BESIDES much valuable information on new forms of microscopic life, and on microscopes, their associated apparatus, and their methods of use, detailed in the various papers and abstracts of papers, we find in this June Number of the R. M. Society's Journal (at pages 381–387, and p. 549) an interesting and carefully prepared account of the fossil *Diatomaceæ* of the London Clay, discovered by W. H. Shrubsole, F.G.S.; a coloured lithograph is supplied in illustration. These are in a pyritized condition, and are very abundant in the lower part of this formation, in a particular zone (366 feet from the surface at Southend), extending over several square miles, at Sheppey, and in the neighbourhood of London. They appear, even to the well-diggers, as "shining spots" in the dry clay, "as if it had been dusted with powdered sulphur, and sparkling in sunlight."

The method of separating these minute mineralized bodies from the clay is given, together with remarks on their occurrence in the different sections and well-diggings that were specially examined. In some parts of the diatomaceous zone, the clay is somewhat laminated by their presence. The pyrites has wholly replaced the original silica in the majority of specimens examined, but occasionally some individuals partially retaining their siliceous condition have been discovered, especially by Dr. Bossey, whose description of the method best adopted for their isolation is also given.

Mr. Kitton supplies a list of the genera and species recognized by him. Among these, *Coscinodiscus* supplies by far the greatest number. Dr. Bossey, Dr. Stolterfoth, Mr. G. D. Brown, and Mr. Shrubsole have met with other forms, also enumerated here. Eighteen genera altogether have been observed.

At page 387, Mr. Kitton makes a very valuable observation, not unlooked for in some quarters, namely, the occurrence of *Diatoms* in the Chalk, as stated by Ehrenberg, is undoubtedly erroneous; the few forms figured by him being from fresh-water, and probably quite recent. That there may have been, and probably were, Diatoms in the Chalk, and subsequently converted into calcic carbonate (according to Sollas), is duly stated in a note at the foot of the same page.

Some geological notes occur also in the excellent "Summary of Current Researches," etc., with which the enthusiastic Editor and his energetic Assistants enrich the Journal. Notices of the fossil Bryozoa (Polyzoa) of New Zealand, by Rev. J. E. Tenison-Woods, and of Australia by A. W. Waters, are given (pp. 429 and 430); and are appropriately associated with remarks by W. A. Haswell, on twenty-seven new forms from the Queensland coast (p. 439). Dr. G. J. Hinde's fossil Sponge Spicules from the Chalk (p. 471), and Green's Foraminiferal banks in the Isle of Ely (p. 473), are also referred to.

T. R. J.

REPORTS AND PROCEEDINGS.

GEOLOGICAL SOCIETY OF LONDON.

June 22, 1881.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Description of a new Species of Coral from the Middle Lias of Oxfordshire." By R. F. Tomes, Esq., F.G.S.

The species of Coral described in this paper was referred by the author to the genus *Thamnastræa* and the subgenus *Synastræa*, under the name of *Thamnastræa Walfordi*, in honour of its discoverer, Mr. E. A. Walford. The specimen was from the *Spinatus*-beds of the Marlstone, at Aston-le-Walls, Oxfordshire. Like *Thamnastræa Etheridgei*, previously described by the author (Q.J.G.S. xxxiv. p. 190) from the Middle Lias of Oxfordshire, this species presents the same subgeneric characters as *T. arachnoides* of the Coral Rag of Steeple Ashton; and the author remarks upon the fact that the only species known from the English Lias resemble Corallian rather than Inferior-Oolite forms.

2. "Note on the Occurrence of the Remains of a Cetacean in the Lower Oligocene Strata of the Hampshire Basin." By Prof. J. W. Judd, F.R.S., Sec. G.S. With a note by Prof. H. G. Seeley, F.R.S.

The author referred to the rarity of remains of marine Mammalia in the Lower Tertiaries of Britain, the only recorded species being

Zeuglodon Wanklyni, Seeley, from the Barton Clay. The single specimen in his possession was obtained at Roydon, about a mile and a half north of Brockenhurst, where the beds exposed in the brickyard consist of sandy clays crowded with marine fossils, and resting upon green freshwater clays, with abundance of *Unio Solandri* belonging to the Headon series. The author briefly referred to the question of the horizon of these deposits, which he regards as belonging to the same great marine series as the beds of Brockenhurst and Lyndhurst, which he holds to be Tongrian or Lower Oligocene.

The Cetacean vertebra obtained by Prof. Judd was stated by Prof. Seeley to be a caudal vertebra, probably the eighth, but not later than the twelfth, of a species belonging, or closely related to the genus *Balœnoptera*, and especially approaching *Balœnoptera laticeps*, a species of the North Sea, which appears to range to Japan. Prof. Seeley regarded it as representing a new species, which he named *Balœnoptera Juddii.*

3. "Description of a Peat-bed interstratified with the Boulder-drift at Oldham." By G. H. Hollingworth, Esq., F.G.S.

The author described a deposit of peat interstratified with Boulder-drift, exposed in a railway-cutting at Rhodes Bank, Oldham. The depth of the section was only 14 feet, and it showed:—

1. Soil	8 to 10 inches.
2. Boulder-clay, with beds and strings of peat	2 to 6 feet.
3. Main bed of peat, containing mosses, exogenous stems, and beetles	2 inches to 1 ft. 9 in. (average 15 inches).
4. Fine blue clay (floor)	2 inches to 1 foot.
5. Current-bedded coarse sand and fine gravel	4 inches to 2 feet.
6. Boulder-clay.	

The mosses in the peat are of northern type.

4. "Silurian Uniserial *Stomatoporæ* and *Ascodictya*." By G. R. Vine, Esq. Communicated by Prof. P. Martin Duncan, F.R.S., F.G.S.

For the genus *Stomatopora* the name *Alecto* has priority; but as that had previously been applied to a member of the class Echinodermata, the author preferred the later name. Species of the genus have also been described under the generic name *Aulopora.* The author has received from Mr. Maw more than two hundredweight of washed *débris* of Wenlock shale, about thirty pounds of which, from twelve localities, he has examined. It contains a moderate amount of Polyzoan remains, generally water-worn. The author described the following species:—*Stomatopora inflata* and *dissimilis, Ascodictyon stellatum* and *radians* (with a variety *Siluriense*), and discussed the characters of the genera.

5. "Note on the Diamond-fields of South Africa." By E. J. Dunn, Esq. Communicated by Prof. Ramsay, F.R.S., F.G.S.

The passes or necks of decomposed gabbro, etc., at the Kimberley, Bultfontein, and other diamond mines have now been excavated to a considerable depth, and have allowed excellent sections of the sedimentary beds through which they have broken to be examined. These are generally but little disturbed, and may be traced over an area of many square miles. Immediately beneath the surface are, generally, yellowish shales, with remains of small Saurians; and beneath these a mass, certainly more than a hundred feet thick, of black carbonaceous shales, with occasional thin bands of coal. It is found that the diamonds are more abundant and of better quality when the level of the black shales is reached. It seems, therefore, not improbable that the carbon requisite for the formation of diamonds was obtained from these shales. Some other points of minor interest were also noted in this paper.

6. "On a new *Comatula* from the Kelloway Rock." By P. H. Carpenter, Esq., M.A., Assistant Master at Eton College.

The specimen, to which the author's attention was called by R. Etheridge, jun., Esq., is in the National Collection; he proposes for it the name *Actinometra calloviensis.* The specimen is from the Kelloway rock, of Sutton Benger; the whole diameter is 15 mm.; diameter of centrodorsal ·6 mm. Three species of this genus are already known from the British Jurassic rocks; two are only known from their centrodorsals, which are each different from that of *A. calloviensis;* the third is *A. cheltonensis*, from the Inferior Oolite, known only by its radials and basals, which are different from those of the present specimen. To this *Antedon Picteti*, from the Valangian of the continent, has some resemblance. It is, however, a true *Actinometra*, differing chiefly from existing forms in retaining its primary basals without their having undergone transformation into a rosette.

7. "Descriptive Catalogue of Ammonites from the Sherborne District." By Sydney S. Buckman, Esq.

In this paper the author gave a list of the Ammonites from the Inferior Oolite of the neighbourhood of Sherborne, in which he enumerated about 47 species, and stated that he had about 50 more which appear to be undescribed; fully one-half have the mouth-termination perfectly preserved. The author indicated the zones into which the rocks furnishing these Ammonites could be divided, as shown at Oborne, near Sherborne, at Wyke Quarry, and at Bradford Abbas, and indicated the characteristic fossils of each; he also gave the principal synonyms of the species referred to, and discussed some of their characteristic peculiarities.

CORRESPONDENCE.

THE PLIOCENE BEDS NEAR CROMER.

Sir,—I have read with much interest the address of my colleague, Mr. Blake, of which an abstract was given in the Geol. Mag. for June. There are, however, one or two points in it to which I must take exception. Mr. Blake may be, and probably is, right in considering that the Weybourn Crag is the equivalent of the Chillesford Clay, but I have avoided correlating them, for at present there does not appear to be any satisfactory evidence either for or against this view. The exact correlation of the different Pre-glacial soils is also very unsafe, and near Cromer probably incorrect.

With regard to the division between Pliocene and Pleistocene, Mr. Blake brings forward no evidence for altering the line I have provisionally drawn; and until some reason is given, I think the *Leda myalis* Bed may be left with the Crag. A land surface, as we know from the Purbecks and Coal-measures, does not necessarily mark a break in the series.

While agreeing with Mr. Blake that the term "Forest Bed" is a misnomer, the suggested alteration to "Rootlet Bed" seems a good deal worse. As well might we class together the London and Oxford Clays, because at the present day the roots of the same species of trees penetrate both. The rootlets of the Forest Bed penetrate whatever happens to be underneath them; sometimes the Weybourn Crag, sometimes higher beds. Even if names are not quite correct, it is better to accept them with a slightly altered meaning than to upset all our nomenclature for every fresh theory. Therefore I think the name "Cromer Forest Bed," having now been in use for over 50 years, ought not be changed, but should be accepted with the meaning that it consists of a series of sub-aerial, lacustrine, and estuarine beds formed in, and from the débris of, a forest-clad country.

Mr. Blake uses the name "Bure Valley Beds" for what was termed the *Leda myalis* Bed; but I have already shown that Messrs. Wood and Harmer's typical Bure Valley fauna comes from the Weybourn Crag beneath, instead of above, the Forest Bed,[1] while at present the *Leda myalis* Bed has not been recognized in the Bure Valley. The test of thickness is of no value in these shallow-water beds; for after they have once reached the sea-level, they may remain for an indefinite time without either erosion or deposit. In our British Pliocene beds it should be remembered we have only the feather edge of a formation, which must be much thicker where the water was sufficiently deep, and perhaps might equal the 700 or 800 feet of the Sicilian Newer Pliocenes. I am astonished at Mr. Blake's statement that the thickness of the beds between the Cromer Till and the Chalk never exceeds 30 feet; the *average* measured thickness exceeds that amount, and at Happisburgh I have reason to believe that the Forest Bed alone is more than 60 feet, for I have dredged and found it in place in 10 fathoms near the shore, and it extends upwards to high water. CLEMENT REID.

HORNSEA, HULL, 6*th June*, 1881.

OBLIQUE AND ORTHOGONAL SECTIONS.

SIR,—If Mr. Day will examine the figure given with his letter in the March Number of this MAGAZINE, he will perceive that Mr. Fisher's 'cavils' are well founded. Not only has Mr. Day interchanged the symbols a and β, but his angle ϕ has no connexion whatever with anything in Mr. Fisher's paper. Mr. Fisher might no doubt have given a simpler proof of each of his equations (2) and (3) by the method indicated by Mr. Day, but one figure would not then have sufficed for the whole proof.

Mr. Day's suggestion of casting a shadow in sunlight, in order to find the form of outcrop, is, as Mr. Fisher readily admits, useful, but he does not tell us how to carry out the inverse process, viz., given

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[1] See GEOL. MAG. Dec. II. Vol. IV. p. 300; and Vol. VII. p. 548.

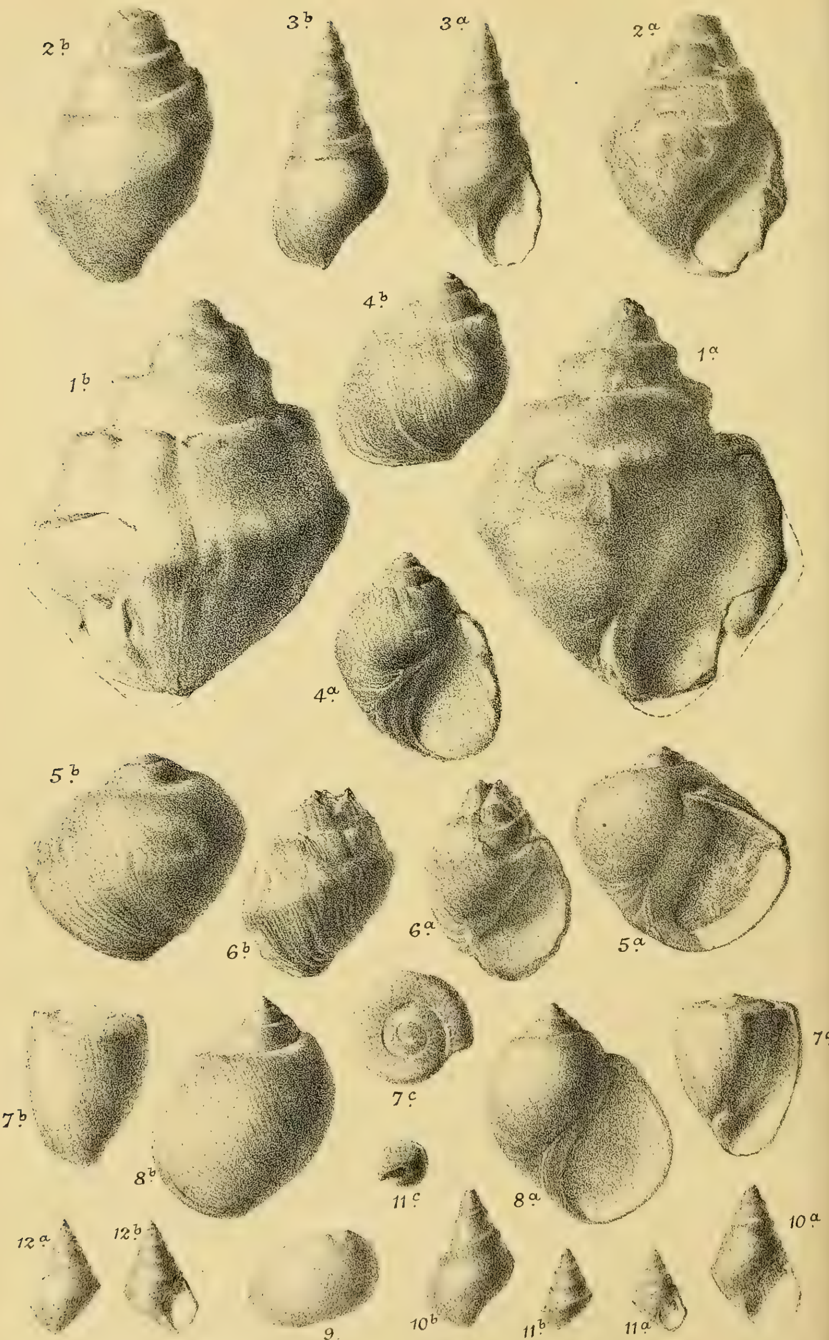
an outcrop, to find form of furrow; an operation to which Mr. Fisher's equations are at once applicable. The rest of his remarks appear to have been written in great haste, and are singularly inaccurate. Does he mean to say that when he has again interchanged α and β, his equation proved on p. 142 even looks like Mr. Fisher's equation (2)? Again, how can he suppose that (p. 142, l. 10) Mr. Fisher assumes the trail to lie in one plane, when it has been expressly stated to lie in a "surface which may be formed out of a folded plane." His figure, on p. 142, represents an altogether different set of angles to Mr. Fisher's. It can, however, be used to prove equation (2) if the following description be substituted for that given in the text.

Let AB, CD be horizontal lines in the inclined plane.
AF, BE lines perpendicular to the inclined plane.
$CDEF$ a horizontal plane.
CE a line of strike, supposed horizontal.
Then $ECD=\alpha$; $BDE=\beta$; $BCD=\phi$

$$\text{And } \tan\phi = \frac{BD}{CD} = \frac{DE\cos\beta}{CD} = \cos\beta\tan\alpha.$$

Christ's College, Cambridge. A. F. Griffith.

Colliery Explosions.—A Parliamentary paper which was issued yesterday throws very important, and in one point unexpected, light on the causes of colliery explosions. After the Seaham accident last Sept. Sir William Harcourt requested Prof. F. Abel, the chemist to the War Department, to report on some samples of dust which had been collected in the workings where the explosion took place. Prof. Abel has now reported the results of his experiments, which entirely confirm those which Mr. W. Galloway has described to the Royal Society. Mr. Galloway showed that though a mixture of air and coal dust was not explosive, it became so when a very small, and apart from the coal dust, an innocuous, quantity of fire-damp was mixed in the air. Prof. Abel's experiments show that not coal dust only, but any dust, even calcined magnesia, will act in the same way. The proportion of fire-damp which is needful to bring dust of any kind into operation as an exploding agent is below the smallest amount which can be detected in the air of a mine, even by the most experienced observer, by the means at present in use. Coal dust shows a tendency to become inflamed and to propagate flame when it comes in contact with a large volume of flame, such as is made by the firing of a shot, and may thus convey the fire from a safe part of a mine to an unsafe part. These discoveries, which finally confirm a long existing opinion, impose a new duty on colliery owners and inspectors. They offer an explanation of many mysterious colliery accidents, and suggest the means of preventing them in the future. There are two sources of explosion, and we have been only guarding against one of them. Henceforth, it is not only fire-damp, but what we may call fire-dust, that must be looked after, and a great decrease of explosions will probably result.—*Daily News*, June 21, 1881.



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Gasteropoda from the Portland Rocks.

THE
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NEW SERIES. DECADE II. VOL. VIII.

No. IX.—SEPTEMBER, 1881.

ORIGINAL ARTICLES.

I.—NOTE ON SOME GASTEROPODA FROM THE PORTLAND ROCKS OF THE VALE OF WARDOUR AND OF BUCKS.

By WILFRID H. HUDLESTON, M.A., F.G.S.,
President of the Geologists' Association.

(PLATE XI.)

FOR many years English palæontologists were content with the limited number of Portlandian Gasteropoda described by Sowerby—principally from internal casts—in Fitton's celebrated paper on the "Strata below the Chalk." Other authors have described a stray species here and there: still the list was scanty, and not only scanty but indefinite; and many ingenious guesses have been hazarded as to the true affinities of such species as *Buccinum angulatum*, and *Buccinum naticoides.*

Until a very short time ago the following may be regarded as a full list of the Gasteropoda of the Portland limestones of this country, viz. *Buccinum angulatum*, Sow., *Buccinum naticoides*, Sow., *Natica elegans*, Sow., *Cerithium Portlandicum*, Sow., *C. concavum*, Sow., *Neritoma sinuosa*, Morr. (Sow.), *Pleurotomaria rugata*,[1] Benett. Of these, "*Buccinum naticoides*" (? *Ampullaria elongata*, Benett) is stated by Damon to be one of the prevailing fossils of the Roche. Mr. Blake also notes it as one of the fossils of the building stones of Portland Isle. It is presumable, therefore, that a form does exist to which this name may apply, though its affinities have never been investigated. The identifications in other districts seem to me very doubtful, and in many cases are probably nothing more than squeezed casts of *Natica elegans*. *Buccinum angulatum* is better known to collectors, though hitherto only found as a cast. It is certainly not *Pteroceras Oceani*, as has been suggested by some, and its true position and affinities have long remained a subject for speculation. Should the conjecture hazarded below prove to be correct, the corresponding shell will have been found at last.

Thus, out of seven species enumerated, one is very doubtful, whilst correct descriptions of some of the others are wanting. Yet, until the appearance of Mr. Blake's paper,[2] this was all the information available with respect to the Gasteropoda of our Portland Rocks

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[1] It is scarcely worth while to include *Littorina paucisulcata*, Phillips, in this list.
[2] Portland Rocks of England, Q.J.G.S. (1880) p. 225.

as far as could be deduced from the works of English authors. On the Continent greater attention had been paid to the subject, and the Portlandian fauna of the neighbourhood of Boulogne received ample illustration at the hands of De Loriol and Pellat. Up to the present time, about 21 species of Gasteropoda have been enumerated by those authors from the Upper Portlandian of Boulogne, and still more from the very fossiliferous Lower Portlandian (zone of *Am. gigas*). Some of these Mr. Blake has recognized in our English Portland Rocks, whilst he has himself contributed other species to the list; of these latter the most important is the well-marked and rather abundant *Natica incisa.*

On the whole it is evident that the fauna of the Portland Limestones of England is not so restricted as, a few years ago, people were content to suppose, but it is peculiar, and it is to some of these peculiarities that I would direct attention in the present communication.

As the concluding stage of the Jurassic system the effects of the impending change would naturally be felt; the marine area was becoming more restricted, and a number of creatures found themselves impounded in shallowing lagoons, and had to make the best of the circumstances. To a certain extent *some* of the Portland Beds, especially in the Vale of Wardour, may be really regarded as the precursors—not only in time but in type—of the Purbecks: that is to say, they were semi-estuarine, or fluvio-marine. This may serve to account for the indefinite character of some of the fossils and the difficulty of placing them generically. It is certain that the Portland Rocks of the Vale of Wardour, and more or less of other districts, divide naturally into two very distinct types.

The principal type is thoroughly marine. This is the one best known to geologists; it is characterized by large Ammonites, and by a fair quantity of very large bivalves, such as *Pecten lamellosus, Cardium dissimile, Trigonia gibbosa,* etc. The species are few, and the specimens too often occur as internal moulds only; still the general facies is very recognizable, and is the one which is to be seen in the majority of quarries, where people have been content to pick up a few of these big ugly fossils, and to come away with the notion that little else was to be obtained. It should be observed that some very interesting fossils have been found of late even in this type of rock.

Far otherwise is the facies of the second type, which may possibly have been connected with the discharge of some river. It is distinguished by one or more species of *Cerithium* in great abundance, together with *Neritoma sinuosa* and *Cyrena rugosa* in greater or less quantity. Sometimes all three are present; occasionally one or the other may be rare or absent. With these are associated some of the shells of the first or megalomorphic type—but always much smaller—together with many species not found in the first type. It is very interesting ground for the palæontologist, in those beds where the shells have been preserved, and it is in this direction that we may hope in future to enlarge the list of Portland fossils.

All the indications go to show that considerable difference of conditions prevailed during the deposit of these two sets of calcareous rocks, though perhaps it is nowhere so strongly marked as in the Vale of Wardour, where the following may be regarded as the complete sequence between the Purbecks and the Kimmeridge Clay in descending order:—

1. Upper *Cyrena*-beds (Uppermost Portlandian), where all the fossils occur as casts, so that specific identification is rendered difficult. *Cerithium Portlandicum* is the characteristic univalve. *Neritoma sinuosa* occurs sparingly.
2. The chalky series. This is thoroughly marine, and contains the usual large Portlandian fauna, along with some forms which strike one as somewhat peculiar.
3. The *Cyrena*-beds—properly so-called. This group, which is somewhat variable, but usually occurs in three blocks, having a total thickness at the maximum of about eight feet, constitutes the most interesting feature in the Vale of Wardour. Here the *Cyrena* type attains its most complete development, and fortunately the shells are in an exceptional state of conservation. Perfect specimens of *Cyrena rugosa* are to be had in abundance, and with these are associated *Cerithium concavum*, Sow., occasionally in great numbers, together with many interesting univalves and bivalves, some of which are described in the sequel.
4. The main building stones. Beds of gritty limestone with much glauconite, containing the usual large Portlandian fauna. There seems to be a considerable break at the top of this series, whilst below it graduates into
5. Impure, subcalcareous sands and clays, with bands of *Trigoniæ* and other fossils at intervals.

In Bucks the equivalents of the *Cyrena*-beds are not so well marked, and *Cyrena* itself is hardly known to me. But there are indications of peculiar conditions which may especially be noted in the uppermost beds of the series, and in portions of the "creamy limestones," where Gasteropoda are more than usually numerous on a certain horizon in particular quarries.

It is hoped that the above brief explanation may render the geological position of the fossils about to be described pretty clear to those who care to investigate the subject.

1. PURPUROIDEA PORTLANDICA, sp.n. Plate XI. Figs. 1*a*, 1*b*.

Description.—Specimen from the Portland limestone of Ashendon, Bucks.

Length	58 millimètres.
Width	42 ,,
Length of body-whorl to entire shell	70 : 100.
Spiral angle	78°.

Shell short, subturrited, angular, scarcely umbilicated. Spire, about five whorls, separated by a suture, which becomes very deep anteriorly. The contour of each whorl is angular; upper margin tabulate and terminating in a salient border or keel from which the sides fall steeply, and even with a certain amount of excavation, towards the lower keel, which, except in the body-whorl and a portion of the penultimate, is hidden by the overlap of the succeeding whorl. These keels were strongly tuberculate; the tuberculation commencing in the third or fourth whorl, and increasing till in the posterior keel of the body-whorl the ornamentation was very decided.

The body-whorl occupies about $\frac{7}{10}$ths of the total height of the shell, and preserves the angular outline of the rest of the spire. The second or median keel divides it somewhat unequally. This keel, though probably less tuberculated, was more prominent than the upper one: below it the body-whorl tapers rapidly towards the anterior margin. The aperture is wide and semi-ovate, without much excavation of the columella, which was covered by a callus of some extent. The only trace of an umbilicus is a slight groove towards the base of the columella.

The ornaments of this fine shell were doubtless more prominent originally. The tuberculations have been softened down, and all traces of finer lines, if any such existed, have been removed. The whole appearance of the fossil indicates that it has suffered from a sort of solvent action, and the anterior portion is not sufficiently well preserved to show the notch.

Relations and Distribution.—If it be admitted that the shell above described is entitled to be ranked in the subgenus of *Purpura* called *Purpuroidea* by Lycett, it is, according to our present knowledge, the only representative of the Purpuroids in the uppermost Jurassic rocks. The group has not hitherto been known either in England or on the Continent on a higher horizon than the Coral Rag. As might be anticipated, the nearest allied forms appear to be those of the *P. nodulata* group. The proportions of Young and Bird's species are nearly the same as in this case, but the contour of the whorls differs materially, perhaps fully as much as does the ornamentation. On the other hand, some persons might be disposed to erect *Purpuroidea Portlandica, Pseudomelania percincta, Natica rugosa* and even *Natica incisa* into a genus having Naticoid affinities, but which possess also other characters which can scarcely be reconciled with those of *Natica.* If *Purpuroidea Portlandica* should ultimately be shown to have an anterior groove, it must be removed from the other three, whose apertures are certainly entire anteriorly.

The specimen now figured was found most probably in the "creamy limestones" of Mr. Blake's classification, and is at present unique as a shell. Nevertheless it is extremely probable that this is the external form of *Buccinum angulatum*, which Sowerby describes as "fusiform, short; sides of spire straight; the last whorl has one keel in the middle; aperture rhomboidal with a short rounded beak." The small amount of slope in the sides of the spire is very characteristic of *P. Portlandica*, and the median keel is another connecting feature. It should be noted that in the specimen from Ashendon a portion of the shell is broken away near this keel, so as to disclose the cast, and we at once observe that the mark of the keel in the cast is not at all equal to the prominence of that on the shell. This disposes of the possible objection that the keel of *P. Portlandica* was much too strong for the cast with which it is sought to identify it.

Buccinum angulatum is pretty common in the Roche of Portland, and has been noted in the uppermost Portland stone of Swindon. Should it turn out to be the cast of the species above described, *P. Portlandica* becomes *P. angulata*, Sow., and its distribution coincident with that hitherto ascribed to *Buccinum angulatum.*

2. Pseudomelania ? percincta, sp.n. Plate XI. Figs. 2*a*, 2*b*.

Description.—Specimen from the *Cyrena*-beds of Alford Quarry, near Tisbury.

Length (restored)	43 millimètres.
Width	24 ,,
Length of last whorl to entire shell	60 : 100.
Spiral angle	62°.

Shell oblong, angular, not umbilicated. Three whorls and part of a fourth remain; the complete number would be about six. Spire moderately elevated, with, probably, a fairly acute apex. Whorls very angular, the posterior border being channeled, though not deeply. Sides of the whorls almost flat, with a tendency towards hollowing out in the anterior ones; slope of each whorl regular and nearly in accordance with the spiral angle. In the posterior whorls the median keel is probably concealed by overlap, but it is very characteristic of the body-whorl, which occupies about $\frac{6}{10}$ths of the spire. Entire shell smooth, as far as can be learnt from its present condition; aperture oval, and somewhat elongate, and but moderately excavated in the columellar region. Shell substance thick. Hardly a trace of an umbilical groove.

Relations and Distribution.—It is perhaps more difficult to fix the generic position of this peculiar shell than of the preceding species. It has strong affinities with a well-known form which occurs in the Dogger and Scarborough Limestone (Inf. Ool.) originally figured by Phillips (G.Y. pl. iv. fig. 29) as *Phasianella cincta*, and afterwards described by Morris and Lycett (Ool. Mol. p. 113, pl. xv. fig. 20) as *Natica ? (Euspira) cincta*. We are apt to regard *Euspira* as a sub-genus of *Natica*, yet neither this nor Phillips's species has the semilunar aperture of that great group. A more remotely-allied form, with a shorter spire, has been described from the Lias of Redcar by Tate and Blake (Yorkshire Lias, p. 349, pl. x. fig. 13), as *Natica purpuroidea*, "which is evidently congeneric with *Ampullaria angulata*, Dunk., quoted by Brauns under *Purpurina*."

Such forms seem to have affinities on the one hand with the Naticas, but yet more strongly with the so-called Phasianellas, Chemnitzias and Pseudomelanias, and only await further recognition to be placed in a distinct genus, whose appearance may probably be held to indicate partly estuarine conditions. Throughout the long interval between the Scarborough Limestone and the Portlandian no such form is known to me in the Jurassic rocks of this country; but, after making due allowance for differences of mineralization, one might be disposed to admit such a shell as *Natica Beaugrandi*, Lor. (Jurass. Sup. de Boulog., vol. i. p. 92, pl. viii. fig. 22), from the Upper Portlandian of La Crèche, into the group.

3. Pseudomelania rugosa, sp.n. Plate XI. Figs. 6*a*, 6*b*.

Description.—Specimen from the "creamy limestones" near Aylesbury, Bucks.

Shell oblong, angular, rugose, not umbilicated. The spiral angle is between 70° and 75°, but the spire itself is too much injured for proportional measurements in so rugged a shell. The height of the body-whorl is evidently considerable in proportion to the rest of the spire, and the sides preserve the same slope. A very strong keel is developed a little above the middle of the whorl, to which it thus imparts an angular character. The upper part of the whorl is excavated, whilst the anterior portion tapers rapidly to the base. The entire shell is ornamented with broad transverse ribbing, probably decussated by fine longitudinal (*i.e.* transverse to the axis) lines: in the body-whorl this transverse ribbing is subdivided by what looks like exaggerated lines of growth. Shell substance very thick: aperture oval to semilunar. Scarcely a trace of umbilicus.

Relations and Distribution.—This very curious shell might almost be taken as the type of these Natico-Chemnitzoid forms, having affinities with *Pseudomelania percincta*, on the one hand, and with *Natica incisa*, next to be described, on the other. The general contour of the shell, and especially the strong median keel, connects it with the first named, and the almost total absence of an umbilical groove is a further bond of union. On the other hand the aperture is more naticoid, and the rugose habit of the shell rather serves to connect it with *Natica incisa*. If we are to regard it as a *Natica*, it may be looked upon as exhibiting an extreme phase of the angular varieties of that genus, and in the great development of the median keel it affords an instance of the tendencies of the period, felt in more than one group of shells, and which received its supreme expression in *Neritoma sinuosa*.

No other specimen has yet been found.

4. NATICA INCISA, Blake, 1880. Plate XI. Figs. 4*a*, 4*b*.

Natica incisa, Blake, 1880, Q.J.G.S. vol. xxxvi. p. 229, pl. ix. figs. 1, 1*a*.

Bibliography, etc.—This species was first noted by Mr. Blake in the "creamy limestones" of Coney Hill and Quainton in Bucks, associated with *Natica ceres*, Lor., to which he considered it to be somewhat nearly related.

Description.—Specimen from the *Cyrena*-beds of Alford Quarry, near Tisbury.

Length	26·5 millimètres.
Width	22 ,,
Length of body-whorl to entire shell	70 : 100.
Spiral angle	88°.

Shell ovate, subangular, moderately umbilicated. Spire rather short, with sharp apex: it consists of about five whorls, separated by a well-marked suture; posterior margin of each whorl flat and indented. Body-whorl large, subangular, and characterized by a broad depression running longitudinally (*i.e.* transverse to the axis of the shell) along the upper part, so as to produce a slightly bicarinated appearance. The deep sulci on the tabulate posterior margin of the whorls may be traced across the flanks of the shell; between these are finer lines of growth: general aspect of the ornamentation slightly rugose (often softened down by action of solvents), with traces of fine longitudinal lines. Aperture wide and semilunar, with a thick callus on the columella: considerable umbilical groove.

Relations and Distribution.—As before stated, this shell has been regarded in its relations with *Natica ceres*, which is said to be common in the Upper Portlandian of Wimereux. It is, however, less globular, has a smaller spiral angle, is more rugose, and would seem to attain to a larger size. *Natica ceres*, according to our present knowledge, is confined in this country to a limited horizon in the "creamy limestones" of Bucks, whilst the species under consideration has a wider range. In an opposite direction its affinities with such a form as *Ps. rugosa* have been already indicated, yet it is decidedly more Naticoid, and, although differing somewhat from the typical *Naticæ*, may be regarded as belonging to a section of that genus exhibiting peculiar modifications. There is a form, for instance, in the Lower Lias of the East of France, figured and described by Piette (Terq. and Piette, p. 31, pl. i. fig. 15–16) as *Natica plicata*, which, as far as the figure goes, possesses considerable resemblance to *Natica incisa*. It is difficult to ascertain how nearly the two are related, since the description of *N. plicata* would seem not to coincide exactly with the figure: yet it is evident that *Natica plicata* of the Lower Lias is a member of this section of the genus.

Natica incisa is pretty widely distributed on a certain horizon in the "creamy limestones" of Bucks, and is tolerably numerous in the *Cyrena*-beds of the Vale of Wardour, where, perhaps, the average size of the specimens is greater than in Bucks. Mr. Blake quotes it from the Portland Sand of Portland, where it would seem to be a little out of place, as there is no record of its occurrence in the limestones except those belonging to the *Cyrena* type. Something like it occurs in the Roche, but the specimen is too imperfect to be referred to *N. incisa* with certainty.

5. NATICA ELEGANS, Sowerby, 1835. Plate XI. Figs. 8*a*, 8*b*.

Natica elegans, Sowerby, 1835, in Fitton, Trans. Geol. Soc. 2nd ser. vol. iv. p. 347, pl. 23, fig. 3.

This well-known species is merely introduced for purpose of comparison with the other forms. It possesses a somewhat higher spire (angle about 84°) than *Natica incisa*, and the median keel of the body-whorl is scarcely perceptible. The posterior border of the whorls is markedly tabulate without being indented: the contour of the shell is very regular, and, as its name implies, elegant: the ornaments consist of fine lines of growth often exquisitely preserved.

N. elegans is very abundant in the "creamy limestones" of Bucks, where specimens from 10 to 70 millimètres in height may be obtained, showing the same character notwithstanding such differences in size. I have never seen any other than small specimens from the *Cyrena*-beds of the Vale of Wardour, but casts of *Natica elegans* of considerable size occur in some of the Portlandian beds of that locality. It is one of those forms which seem common to both types of Portland limestone.

6. Chemnitzia teres, sp.n. Plate XI. Figs. 3*a*, 3*b*.

Description.—Specimen from the *Cyrena*-beds of Chilmark Quarry.

Length	35 millimètres.
Width	16 ,,
Length of body-whorl to entire shell	46 : 100.
Spiral angle	35°.

Shell moderately elongate, conical, subturrited, not umbilicated. The spire increases under a regular angle of 35°, and consists of about nine whorls (seven preserved), which are well separated by the suture. The posterior portion of each whorl is distinguished by a rounded projection or belt, which serves to conceal the suture, and gives a somewhat turrited aspect to the spire; the whorls have a shallow submedian excavation. Body-whorl smooth and regular, with a slight excavation in the posterior third. The entire shell is devoid of ornament (in its present condition) other than faint lines of growth on the body-whorl. Aperture ovate; columella but little excavated, and not much covered by callus; no trace of an umbilicus.

Relations and Distribution.—This very pretty and regular species is most nearly related to *Melania abbreviata*, Rœm. (Ool. Geb. p. 159, pl. x. fig. 4), subsequently recognized and described by De Loriol (Jurass. Sup. de Boulogne, vol. i. p. 80, pl. viii. figs. 2 and 3) from the Séquanien of Bellebrune, and noticed by me as occurring in the Lower Calcareous Grit of Cumnor, near Oxford. It especially resembles that species in the prominent belt at the posterior margin of each whorl, which almost conceals the suture. It differs from that species in its rounder and softer outlines, in the inferior value of the spiral angle, and in the regularly conical form of the spire. The belt at the posterior border, which characterizes all the whorls up to the very apex, may serve to distinguish it from other species of the so-called Chemnitzias.

This form is tolerably abundant in the *Cyrena*-beds of some parts of the Vale of Wardour, but the state of conservation is usually indifferent. It has not been found elsewhere, as far as I know.

7. Chemnitzia naticoides, sp.n. Plate XI. Figs. 10*a*, 10*b*.

Description.—Specimen from the *Cyrena*-beds of Chilmark Quarry.

Length	20 millimètres.
Width	12 ,,
Length of body-whorl to rest of shell	57 : 100.
Spiral angle	50°.

Shell sub-conical, moderately elongate, not umbilicated. Spire composed of about five whorls, smooth, well-defined by suture, and increasing regularly; no belt distinguishes these whorls, which are slightly excavated. The body-whorl is scarcely tumid, and has a shallow depression in the upper third, which gives emphasis to a slight and well-rounded median keel. Aperture ovate to semilunar: not the least trace of an umbilicus.

Relations and Distribution.—There is really so little to lay hold of in a shell of this sort that its affinities can only be guessed at. It may indeed be a dwarf of some form already known in other countries. Both it and the next described form are found sparingly in the *Cyrena*-beds of the Vale of Wardour.

8. CHEMNITZIA DECUSSATA, sp.n. Plate XI. Figs. 11*a*, 11*b*.

Description.—Specimen from the *Cyrena*-beds of Chilmark Quarry. This form differs from the one last described chiefly in the more strongly defined belt encircling the upper portion of each whorl, and in the ornamentation, which is very obvious at the base of the shell; the aperture also is more oval, and there are some traces of an umbilicus.

Relations and Distribution.—The belt at the posterior extremity of each whorl rather serves to remind one of *Chemnitzia teres*, but *Ch. decussata* is more stumpy in its growth, besides showing considerable traces of ornamentation. The form figured, 12*a* and 12*b*, may perhaps be referred here. Found sparingly in the *Cyrena*-beds of the Vale of Wardour.

9. NERITOMA SINUOSA, Sow., 1818. Plate XI. Figs. 5*a*, 5*b*.

Nerita sinuosa, Sow. 1818, M.C., pl. 217.
Nerita angulata, Sow. 1835, Trans. Geol. Soc. 2nd ser. vol. iv. p. 347, pl. 23, fig. 2.
Neritoma sinuosa, Morris, 1849, Q.J.G.S., vol. v. part 1, p. 334, with figure.
Neritoma sinuosa, Morris (Sow.), 1864, De Loriol et Pellat, Port. de Boulog., p. 35, pl. iii. figs. 19–21.

No description of this well-known species is needed after the very full account given by Morris (*op. cit.*) in his article on *Neritoma*. The species is also well described and figured by De Loriol. As the companion, in so many cases, of the fossils to which this communication relates, a glance at its relations and distribution may not be out of place.

Relations and Distribution.—*Neritoma* would seem to be eminently representative of that sort of generic confusion which prevailed at the time when the Portland Rocks of England received their fossil contents. De Loriol (*op. cit.* p. 37) is of opinion that, in some respects, the shell recalls the peculiarities of certain Naticas, and he even considers that the animal may have approached that type. As a subgenus it is very limited both in range and number of species.

The distribution of *Neritoma sinuosa* is peculiar. It is extremely abundant in the *Cyrena*-beds of the Vale of Wardour, and is also found more sparingly in the upper *Cyrena*-beds (No. 1) of that locality. In the highest Portlandian bed at Swindon, which belongs to the *Cyrena* type, very large specimens occur. In Bucks it is rare, and has only been found in the very topmost beds at Quainton. Of its presence in the Roche of Portland I am not quite certain. It is hardly necessary to mention that this species does not occur in the more purely marine Portlandian beds of any locality.

When we trace its distribution on the Continent, we find that, at Boulogne, *Neritoma sinuosa* is stated to be pretty common in the Lower Portlandian (zone of *Am. gigas*), but is not quoted from the Upper Portlandian — usually held to be the equivalent of our Portland Stone. In Hanover, according to Struckmann, *Neritoma sinuosa* (= *Nerita ovata*, Rœm.) is most abundant in part of the Middle Kimmeridge. Even granting that *Neritoma ovata* is sufficiently different to be regarded as a distinct species—the view taken by De Loriol — we cannot fail to notice with interest the fact that

Neritoma is first observed in the Middle Kimmeridge of N.W. Germany, next in the Lower Portlandian of Boulogne, and finally in certain restricted beds of our own Portland Rocks, but always on a higher horizon in its journey westwards.

There is something very instructive in this, and *Neritoma* is so marked a form that there can be no mistake about it; but a similar lesson is taught by other fossils. If, for instance, we wish to search in N.W. Germany for the representatives of many of our Portlandian Gasteropods, to what horizon ought we to turn? Not certainly to the Upper Portlandian of that country, for it does not contain a single Gasteropod.[1] The Lower Portlandian of N.W. Germany (zone of *Am. gigas*) has a larger and more varied fauna, but we must go as low as the Pteroceras schichten, that is to say, below the equivalents of the mass of the Kimmeridge Clay of England, which is mainly Virgulian or higher, before we recognize anything like an univalve facies corresponding to that of our own Portland Rocks.

10. NERITA TRANSVERSA, Von Seebach, 1864. Plate XI. Fig. 9.

Nerita transversa, Von Seebach, 1864, Der. Han. Jura, p. 131, pl. vii. figs. 1*a*, *b*.
Idem. Idem. 1866, De Lor. et Pell., Port. de Boulog. p. 33, pl. iii. figs. 22-24.
Ibid. varietas *minor*, Lor. et Pell., 1874, Jurass. sup. de Boulogne, p. 105, pl. ix. figs. 16, 17.

This interesting form, which is too well known to need description, is another connecting link between our Portland Rocks and the Middle Kimmeridge of Hanover. It occurs in some abundance in the Lower Portlandian of Boulogne, together with the variety *minor*, which alone occurs in the Upper Portlandian of that district. De Loriol speaks of it as a perfectly typical Nerite living under marine conditions, but one may read the fact the other way, as showing the estuarine character of beds where such shells occur.

In England its occurrence was first noted by Mr. Blake in the *Cyrena*-beds of the Vale of Wardour, where it is met with sparingly. No instance of its occurrence in the more truly marine beds has yet come to my knowledge.

11. ACTÆONINA SIGNUM, sp.n. Plate XI. Figs. 7*a*, 7*b*, 7*c*.

Description.—Specimen from the *Cyrena*-beds of Chilmark Quarry.

Length	20 millimètres.
Width	16·5 ,,
Diam. of last whorl in relation to its length....	0·78.

Shell tumid, not much longer than wide, subcylindrical, attenuated anteriorly. The spire, which scarcely projects, consists of five or six whorls, one within the other. These are faintly convex,

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[1] Subjoined is a complete list, according to Struckmann, of the fossils of the Upper Portlandian of Hanover. *Pecten concentricus*, Dunk. and Koch, *Perna Bouchardi*, Oppel, *Modiola lithodomus*, Dunk. and Koch, *Trigonia variegata*, Credner, *Cardium Dufreynoicum*, Buvig., *Cyprina Brongniarti*, Rœm., *Cyrena rugosa*, Lor. (Sow.), *Cyrena nuculæformis*, Rœm., *Cyclas Brongniarti*, Dunk., *Corbula Mosensis*, Buvig., *Corbula alata*, Sow.

separated by a well-marked suture (Fig. 7*c*), and ornamented with curved scaly marks, which are strongest on the flat posterior area of the body-whorl. The nucleus is represented by a little knob in the centre. The body-whorl is large, and its flanks are rather strongly marked by lines of growth in connexion with the scaly marks on the flat posterior area. The aperture is long, and the outer lip nearly straight for two-thirds of its length, when it curves round with an oval sweep anteriorly. The columella is much excavated anteriorly, but there is no distinct plication on the inner lip, and the traces of an umbilicus are very faint. Shell thin.

Relations and Distribution.—In form and general character this fine species approaches *Tornatina Bayani*, Lor., from the Lower Portlandian of Terlincthun (Boulonnais), but that species is only 6·5 mm. in length, and is much longer in proportion to its width than the Chilmark shell, which may be regarded as intermediate between the above and such a form as *Actæonina ventricosa*, D'Orb., quoted from the Upper Portlandian of Boulogne. It may be worth mentioning that *Tornatina Bayani* occurs in the Pteroceras schichten (Middle Kimmeridge) of Hanover, where it attains a length of 7 mm.

Actæonina signum (De Loriol would probably regard it as *Tornatina*) is moderately plentiful in the highest portion of the *Cyrena*-beds of the Vale of Wardour, towards the junction with the Chalky series (No. 2). It has not yet been noted out of the Vale of Wardour.

There is at least one other well-marked species, which is most probably an *Actæonina*, from the same beds, and I have a large specimen of an *Actæonina* in flint, which was most probably derived from the Chalky series (No. 2). We may therefore regard this group of the Actæons as being tolerably well represented in the Portlandian of the Vale of Wardour.

EXPLANATION OF PLATE XI.

Fig. 1. *Purpuroidea Portlandica*, Hudleston. 1*a*. Front view, 1*b*. back view of shell, nat. size. Portland Limestone, Ashendon, Bucks.

,, 2. *Pseudomelania ? percincta*, Hudleston. 2*a*. Front view, 2*b*. back view of shell, nat. size. Cyrena-beds, Alford Quarry, near Tisbury.

,, 3. *Chemnitzia teres*, Hudleston. 3*a*. front, 3*b*. back view, nat. size. Cyrena-beds, Chilmark Quarry.

,, 4. *Natica incisa*, Blake (1880). 4*a*. front, 4*b*. back view, nat. size. Cyrena-beds, Alford Quarry, near Tisbury.

,, 5. *Neritoma sinuosa*, Sowerby (1818). 5*a*. front, 5*b*. back view, nat. size. Cyrena-beds, Vale of Wardour.

,, 6. *Pseudomelania rugosa*, Hudleston. 6*a*. front, 6*b*. back view, nat. size. "Creamy Limestones," near Aylesbury, Bucks.

,, 7. *Actæonina signum*, Hudleston. 7*a*. front, 7*b*. back, 7*c*. apical view, nat. size. Cyrena-beds, Chilmark Quarry.

,, 8. *Natica elegans*, Sowerby (1835). 8*a*. front, 8*b*. back, nat. size. "Creamy Limestones," Bucks.

,, 9. *Nerita transversa*, Von Seebach (1864). Dorsal view, nat. size. Cyrena-beds, Vale of Wardour.

,, 10. *Chemnitzia naticoides*, Hudleston. 10*a*. front, 10*b*. back view. Cyrena-beds, Chilmark Quarry.

,, 11. *Chemnitzia decussata*, Hudleston. 11*a*. front, 11*b*. back view. 11*c*. umbilical view, nat. size. Cyrena-beds, Chilmark Quarry.

,, 12*a*. and *b*. *Chemnitzia* sp. ? Cyrena beds, Vale of Wardour.

II.—On the Lower Keuper Sandstone of Cheshire.

By A. Strahan, M.A., F.G.S., H.M. Geological Survey.

While I was engaged in surveying the Drift-deposits of the neighbourhood of Warrington, Runcorn, and the Peckforton Hills near Chester, my attention was called to what appeared to be a good boundary-line in the middle of the Lower Keuper Sandstone, separating the Waterstones from the Conglomerates underlying them. The sections at Runcorn and Frodsham, where I first saw this line exposed, have been already described with many others in the Survey Memoirs on the Neighbourhood of Prescot (3rd edition) and on the Neighbourhood of Chester. They showed that there was no passage from the Waterstones down into the Conglomerates, but that there was on the contrary a sharp division between them; and as on following this line further south, I found that it was persistent, and everywhere separated beds of a very different nature, it was decided that it should be engraved on the Map, the new classification of the Keuper of this neighbourhood, as contrasted with the old, being shown in the accompanying figure.

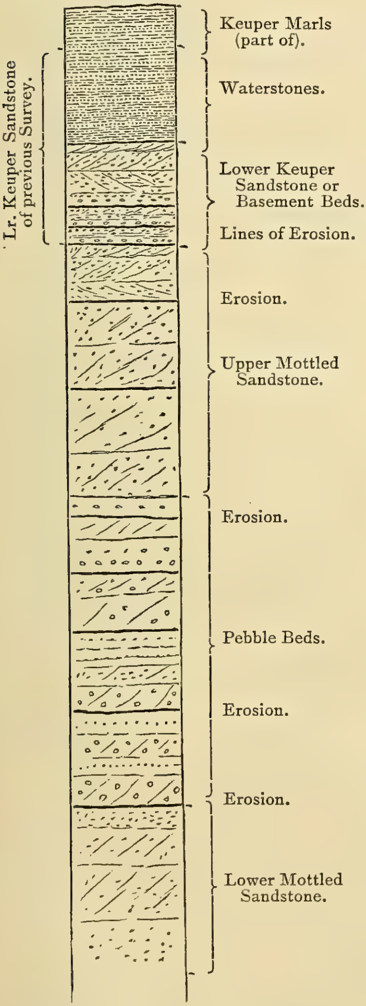
The Lower Keuper Sandstone or Basement Beds consist of quartzose sandstones with a sharp and rather coarse grain, conglomeratic or brecciated in parts and always current-bedded. The bold and craggy escarpment formed by the superposition of these beds on the soft Upper Mottled Sandstone of the Bunter often presents minor features or terraces, resulting from the separation of the harder building stones into courses by partings of softer material. These partings are occasionally formed by a bed of shale, but more usually by a very soft current-bedded mottled sand, of a finer grain than the building stone. The upper part of the subdivision consists of a considerable thickness of this soft sand, as is seen in the Railway Cutting at Frodsham (Geology of the Country around Prescot, Fig. 4), where the current-bedding is on so large a scale as to have been sometimes mistaken for contortion. The beds are arranged in the form of troughs, one within another, and inclined towards the east at a high angle. In the section these troughs are cut across nearly at right angles, so as to present arcs of a number of nearly concentric circles of about 40 yards diameter. For convenience of reference, I gave to these beds the name of the Frodsham Beds. They are persistent over this part of Cheshire, but variable in thickness. In the lower part of the Frodsham Beds, the coarser-grained and harder sandstone comes in gradually, often appearing first in lenticular masses, so that there is a perfect passage downwards.

Every course of the harder sandstone is as a rule conglomeratic and brecciated towards its base, and rests on a slightly eroded surface of the underlying bed. Fragments of shale often occur in irregular lines in the brecciated portion, as though a bed of shale, previously laid down and half hardened, had been torn up and the fragments rolled about, though not moved to a distance. In this respect, and in the frequent repetition of lines of erosion, the Lower Keuper Sandstones resemble those of the Coal-measure age.

From the description of the Frodsham Beds given above, it will be seen that they are similar in character to the Upper and Lower Mottled Sandstones of the Bunter. Indeed even in the field they cannot be distinguished from these subdivisions except by ascertaining their relative position to the conglomerates of the Keuper Basement Beds below and the Waterstones above.

VERTICAL SECTION OF A PART OF THE TRIAS NEAR CHESTER.

Scale 500 feet = 1 inch.



After the deposition of the Frodsham Beds, a complete change must have taken place, for the Waterstones which succeed them are of an entirely different lithological character, and belong to the Keuper Marl type exclusively. They consist of evenly-bedded or laminated, loamy, and micaceous sandstones, alternating with shales, the whole presenting an appearance of extreme regularity of bedding, suggestive of deposition in tranquil water. The peculiar loamy texture and the absence of the conglomeratic character in these sandstones renders them easily distinguishable from the building stones of the Lower Keuper Sandstone, even after removal from the quarry.

The contrast between these two subdivisions and the sharpness of the line dividing them is beautifully shown in the railway cutting at Runcorn Station. The lowest beds of the Waterstones consist of deep red shales and micaceous flags, and rest directly upon the loose current-bedded sand of the Frodsham Beds. At the south end of the cutting the Frodsham Beds are red, but at the north end white, the loss of colour taking place gradually in passing from one end of the section to the other. The same junction is exposed in the road leading from Frodsham to Overton, and in a lane near Overton Church (Geology of the Country around Prescot, fig. 5), on Eddisbury Hill, and in Delamere Forest. Even where good sections are wanting, the line can be followed with ease by the change in the soil, resulting from the juxtaposition of rocks so different in character.

Towards the top of the Waterstones, the sandstones become gradually less numerous, and the shales predominate, so that there is a passage upwards into the Red Marls, in which bands of sandstone are less common, though not absent, the Upper Keuper sandstone of the Midland districts being apparently a repetition in the Marl of beds of the Waterstone type. The line separating the Waterstones from the Red Marls is under these circumstances arbitrary, and can only be regarded as approximately separating the more sandy base of the Marls from the main mass above in which shales predominate. This arbitrary horizon was formerly taken as the upper boundary of the Lower Keuper Sandstone, the Waterstones and the Lower Keuper Sandstone (as now defined) having been hitherto grouped together.

The Waterstones also, like the Red Marls, contain abundantly ripple-marks, sun-cracks, markings supposed to be rain-pittings, and the casts in clay of the cubical crystals of rock-salt. These casts or pseudomorphs appear for the first time in the Waterstones, being unknown, so far as I have heard, in the Keuper Basement Beds.

The Waterstones, in common with the Keuper Basement Beds and the Bunter, are subject to rapid variations in colour. They are usually deep-red, with thin green bands, but on Longley Hill, near Kelsall, they are locally bleached, the sandstones being white, and the shales green with thin red bands. Similarly the Basement Beds at Helsby Hill are brown, but become mottled with white towards the south end of the hill. Two miles to the south, at Manley, they are a pure white, and the lumps of shale included in them are green, sometimes with a red nucleus. At Delamere they are brown again, but in the Peckforton Hills once more white. The Frodsham Beds also vary from a bright-red and yellow at Delamere to a yellow at Manley, while at High Billinge they are bright-red again. At Frodsham they are red, but in the road to Overton snow-white, but at Overton, about one mile from Frodsham, once more bright-red. The change from red to white within a few yards at Runcorn Station has been already referred to. The Upper Mottled Sandstone shows equally rapid changes of colour in a small space at Beeston Castle. On the east side of the hill it is deep red, on the north yellow with veins of iron oxide, on the north-west yellow mottled with red, on the west yellow above and red below, but on the south red above and yellow below. These changes take place within an area of about one quarter of a square mile. The observations on the changes of colour in these rocks are instructive as showing how little reliance can be placed on this character as a means of identifying horizons in the absence of continuous sections.

During the progress of the re-survey of the Keuper in Cheshire, I was informed by Mr. De Rance that the line between the Waterstones and Basement Beds which I was engaged in tracing, existed also in Lancashire, and had been selected by him as the base line of the Marls, no subdivision of the Waterstones being possible, from the prevalence of drift over the area probably occupied by them. I had afterwards an opportunity of visiting with him some of the sections in Lancashire for the purpose of making comparisons. The Basement Beds as exposed at Ormskirk, and in the Orrel railway cutting, are similar to those of Cheshire, and like them are succeeded abruptly upwards by beds of the Red Marl type. The junction is exposed in the Orrel railway cutting, and presents a very similar appearance to the sections at Runcorn and Frodsham, described above. Borings, made subsequently to the survey by Mr. De Rance, have proved that the lower part of the Marls contain sandy beds, corresponding in character and position to the Waterstones of Cheshire. In Liverpool the same sequence has been observed by Messrs. De Rance and Morton. The cemetery shales, which were supposed by Mr. Morton to be intercalated in the Keuper Basement Beds, are now known to be the lower beds of the Red Marl repeated by a fault, so that the supposed discrepancy between the sequence here and in Cheshire is removed.

At the same time Mr. Aveline recognized this boundary-line in Cheshire as the same as that which had been mapped by him as the base of the Waterstones in the neighbourhood of Nottingham. He states in the Geology of the Country around Nottingham (2nd edition, p. 29) that, "Only the Middle and Upper division of the Keuper are fully developed, namely, the Waterstones and the Upper Keuper Marls. But at the base of the Waterstones there often occurs a thin bed or beds of conglomerate resting on the eroded surface or in hollows of the Pebble Beds; below this conglomerate, and lying in hollows in the Bunter, has been found a coarse white sand, much resembling the white Keuper building-stone of Cheshire if pounded."[1] It is stated that the break between the Bunter and Keuper is complete, but Mr. Shipman observes that the Waterstones are seen overlapping the white sandstone on either side and resting on the Bunter, and remarks that "The White Sandstone at Nottingham had evidently suffered some amount of denudation before the Brown Sandstone and the Red Clay of the 'Waterstones' were deposited over it." Two outliers of Waterstones also, according to Mr. Aveline, rest on the Pebble Beds in Beeston Field. Therefore, whether the Keuper Basement Beds of Cheshire are represented or not, it is certain that there is as strong a line at the base of the Waterstones here as in Cheshire, with the additions of a well-marked overlap, and an apparent local unconformity.

At Alton, in Staffordshire, according to Mr. Shipman, "there is a still more decided break (than at Helsby Hill, in Cheshire), indicated by a sudden change in the character of the sediment laid down. The upper surface of the Basement Beds there shows no sign of having been eroded, but the 'Waterstones' are represented by sandy Marls, with sometimes a solitary seam of brown sandstone near the bottom—a marked contrast to the compact coarse pink or white sandstone that forms the base there."[2] This locality is important

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[1] See also J. Shipman, "Conglomerate at the Base of the Lower Keuper," GEOL. MAG. 1877, p. 497, and E. Wilson and J. Shipman, "On the Occurrence of the Keuper Basement Beds in the Neighbourhood of Nottingham," GEOL. MAG. 1879, p. 532.

[2] Nottingham Naturalists' Society, Annual Report for 1880.

as occurring about midway between the areas in Cheshire and near Nottingham, where the sequence has been clearly made out.

This line therefore appears to be persistent over a large area, and to form a strong separation of the Waterstones from the Keuper Basement Beds, even in localities where it was formerly supposed that there was a perfect passage between the two. While surveying in Cheshire, I found that in consequence of the prevalence of shales in the Waterstones in certain districts, they were included in the Keuper Marls, while close by they were mapped as Lower Keuper Sandstone, in consequence of the exposure of sandy beds in them. The upper boundary of the Lower Keuper Sandstone therefore did not follow one horizon, but was taken across the strike of as much as 200 feet of strata. In consequence of this, it was supposed that there was a perfect passage between the Waterstones and the Basement Beds in those localities where it is now known that a sharp line of separation exists.

At this horizon, moreover, the principal overlap in the Trias takes place, for while the Bunter and the Keuper Basement Beds, which are confined approximately to the same limits, thin out along a line drawn from north-east to south-west through Leicestershire (Triassic Memoir, p. 60), the Waterstones, with the allied Marls, run beyond this limit so as to rest directly on Palæozoic rocks, the base of the Waterstones becoming in such cases conglomeratic. A similar overlap of the Marls has been noticed in Devonshire by Mr. Ussher, who considers that at this period for the first time a connexion was established between the Triassic waters of Devonshire and the Midland Couuties.[1]

At this period also the change in the physical geography of the region commenced, which led to the formation of the Red Marls with their associated beds of rock-salt and gypsum. The appearance of the casts of salt-crystals for the first time in the Waterstones, taken in connexion with the uniformly even-bedding, lamination and loamy texture of these beds, points to their having been laid down under conditions totally different from those which produced the sands and conglomerates of the Bunter, and of the Lower Keuper Sandstone. During the period of the Bunter shifting currents must have prevailed, sweeping along from the north (as shown by Prof. Hull) between the hills of Derbyshire and of Wales large quantities of sand and gravelly sediment. The same or similar currents prevailed during the deposition of the Lower Keuper Sandstone, which is not only lithologically similar to the Bunter, but follows it also in its geographical range and development. But after this period, the free circulation of currents ceased, for all the succeeding beds show clear evidence of having been deposited in tranquil water, while the pseudomorphs of rock-salt prove that this water occupied a land-locked basin, in which concentration of brine was taking place. These conditions, appearing for the first time at the base of the Waterstones, prevailed without intermission until the close of the period of the Red Marls.

[1] Quart. Journ. Geol. Soc. Aug. 1878.

In the earlier works on the Trias of Cheshire, the base of the Keuper was placed at this horizon, namely, at the base of the Waterstones, the Keuper Basement Beds being classed with the Bunter (see papers by Mr. Ormerod and others). This classification was changed in 1852 and the following years by Prof. Hull, for reasons which he gives in full in his Memoir on the Triassic and Permian Rocks of the Midland Counties, p. 9. These reasons, stated briefly, are the absence of any sign of a break in the sequence from the Lower Keuper Sandstone up into the Red Marls, but an apparent unconformity between the Lower Keuper Sandstone and the underlying beds.

It seems then that if the separation between the Lower Keuper Sandstone and the Waterstones is as well marked in other districts as in those which have been at present re-examined, the former of these reasons for dissociating the Lower Keuper Sandstone from the Bunter will be done away with, for in those localities which have been described above, though there is no unconformability, there is no passage from this rock up into the overlying Waterstones.

With regard to the second reason, namely, the break at the base of the Lower Keuper Sandstone, it is necessary to avoid overestimating the value of the evidence brought forward in its favour.

It was believed that the Bunter had been upheaved and suffered great denudation before the deposition of the Keuper and that the discordance in the dips produced by these pre-Keuper movements was actually visible in a section at Ormskirk (Triassic Memoir, p. 87). But on examining the section, I came to the conclusion that there was no discordance in the dips of the two rocks, and that certain beds in the Bunter which rise up to and end off against the base of the Keuper, were only a portion of the current-bedding of the former rock, and did not represent its true dip. More striking instances of the cutting off of current-bedding planes may be seen at the junction of the Waterstones and Frodsham Beds (figured in the Memoirs on Prescot and Chester).

Further evidence of the denudation of the Bunter is sought in the fact that the Lower Keuper rests on beds of different colour in Cheshire and Lancashire. For instance, on p. 85 of the Memoir, it is stated that in the southern part of Liverpool "the Keuper Conglomerate is found resting on *red sandstone*, which, as may be seen at the Red Noses on the sea-coast at New Brighton, underlies a considerable series of *yellow sandstone* of the Upper Bunter; the whole of which has in this instance been denuded away before the Keuper period," and again in the Geology of Wigan, p. 32, "the yellow beds are between 200 and 300 feet in thickness, and therefore when we find in any special locality the Lower Keuper Sandstone resting upon the red beds, we are driven to conclude that the whole of this 200 or 300 feet of strata have been denuded away in that place." But I have previously shown how rapidly the Upper Mottled Sandstone and other subdivisions of the Trias vary in colour. This evidence of denudation, resting on the identification of horizons in the Upper Mottled Sandstone by colour, cannot therefore be considered of much value.

Nor again can the appearances of erosion at the base of the Lower Keuper Sandstone be accepted as evidence of the unconformity between the Bunter and Keuper. Not only are these appearances reproduced at the base of every bed of conglomeratic sandstone in the Lower Keuper, but they are equally strong at the base of the Pebble Beds in the Bunter (Triassic Memoir, pp. 35, 36, etc.), while they occur also in the Upper Mottled Sandstone itself. The Frodsham Beds, and soft partings in the Lower Keuper Sandstone, are exactly similar to the Upper and Lower Mottled Sandstones of the Bunter, and the conglomerate beds of the two subdivisions are so alike as to have been wrongly identified in some cases in the first survey of the district. There is therefore a striking similarity between the various horizons at which signs of erosion appear, and there is no evidence in this district that the erosion was greater at the base of the Lower Keuper Sandstone than at any one of the other horizons. These phenomena are not evidences of unconformity, but like the current bedding by which the whole of the Lower Keuper and Bunter are traversed, indicate the action of currents varying in strength and possibly in direction, an increase of strength causing sand already deposited to be partially removed, and coarser sediment to be laid down in its place.

It has been already stated that the Lower Keuper Sandstone has approximately the same geographical distribution as the Bunter. From what has been said of the neighbourhood of Nottingham, it will have been seen that the Lower Keuper Sandstone is on the point of thinning out, though the Waterstones are well developed. The same fact is observable in proceeding southwards from Cheshire to those districts, where the Bunter thins out as described by Prof. Hull, and though it is not possible to give the exact range of the Lower Keuper Sandstone, until the separation of the Waterstones has been completely carried out, yet it may now be stated that over a large area, where Lower Keuper Sandstone is represented on the maps, the Waterstones only are present, without any equivalent of the Basement Beds of Cheshire. In the event of the sharp division of the Waterstones from the Basement Beds being found to hold good over the whole area, and taking into consideration the strong lithological resemblance of the Lower Keuper Sandstone to the Bunter, and the similarity of its distribution, it will have to be reconsidered whether the break at the base of the Lower Keuper Sandstone has not been greatly overestimated, and whether the base of the Waterstones does not constitute a more important stratigraphical horizon in the Trias.

The fossil evidence, so far as it goes, points to an association of the Keuper Basement Beds with the Waterstones, for the *Cheirotherium* footprints are equally well known in both, but this evidence, depending, as it does, on a want of knowledge of the fossil contents of the Bunter, is of a purely negative character. Leaving for the present the difficult question of the correlation of these beds with the foreign deposits, and the vague speculation as to the horizon of the Muschelkalk, it would seem advisable to distinguish the Waterstones for the future, reserving the term Lower Keuper Sandstone for the sandstones and conglomerates, as typically developed in Cheshire.

III.—THE CAUSE OF THE MAMMOTH'S EXTINCTION.

By HENRY H. HOWORTH, F.S.A.

IN a previous paper we showed that the extinction of the Mammoth was sudden, and was accompanied by a sudden change of climate throughout Northern Siberia, which enabled its soft parts to be preserved intact. We did not mean that the change of climate was the cause of the Mammoth's extinction. This it clearly was not, for this change on a large and marked scale was apparently confined to Siberia, while the Mammoth disappeared from a much wider area, where this climatic revolution could not have been so fatal. A sudden change of climate could not account for a catena of Mammoth carcases found *buried several feet underground* from the Obi to Behrings Straits. If they had been killed by the cold merely, their bodies would have lain on the surface where they fell and become long ago the prey of the predatory animals. Nor again can we, with such a postulate merely, account for the remains occurring in many cases in hecatombs, and in many cases also with a mixture of various species of animals. The cold would hardly have destroyed the bears and hyænas which are found linked in a common fate with the Mammoths and Rhinoceroses. Nor, as we shall see, would a mere change of climate, however severe, account for other factors in the problem. The change of climate accounts perfectly for the preservation of the carcases, which preservation again necessitates the conclusion that that change was a sudden or very rapid one; but we have clearly still to seek the real cause of the disappearance of the animals of which the change of climate was a concurrent effect.

In addressing ourselves to this problem, we would again begin by insisting upon the necessity for putting aside *à priori* prejudice, founded upon current geological theories. We had occasion to argue in a previous paper that the doctrine of Uniformity, which has done more than yeoman's service in clearing geological reasoning from a great many immature and *à priori* hypotheses, has been pressed in England to a degree far beyond what students in America or the Continent deem justified by the facts. In former days, when a *deus ex machina* was summoned to explain every slight difficulty, and a cataclysm suggested as the ready cause of every change in the Earth's crust, it was necessary that some one with vigour and energy should point out that the best and most fruitful way to study the past history of the globe was not to have recourse to cataclysm, at every turn, but to learn how changes were being effected now, and to base our induction upon such a study. This was most necessary; but it was inevitable that this course of reasoning should in turn become exaggerated, until we find it gravely asserted that the pinnacled mountains of the Sierra Nevada in Spain, the Cañons of the Colorado, the fiords of Norway, the boulders that overspread Finland and Sweden in such profusion and of such magnitude, *et id genus omne*, were the results of precisely the same forces, *both in kind and degree*, that are at present at work upon the earth. A view which is entirely repudiated by the more judicial authorities beyond our seas, who have not the same close ties with and obligations to Lyell that we have.

Again, it is the fate of views which have been pressed fanatically on other than merely scientific grounds that they not only cause science to stiffen her upper lip, but that they react in a mischievous way by making scientific men shrink from, if they do not repudiate, perfectly legitimate modes of argument, and classes of evidence which have been perverted to merely polemical purposes. Because the universal deluge was once insisted upon by the partizans of theology, and was as stoutly opposed by science as being utterly at issue with the evidence, therefore any form of diluvial movement on a large scale, in comparatively recent times, aroused the suspicion and antagonism of those who were afraid the cloven hoof might at any moment be thrust forward.

Again, because theology quoted as infallible, certain documents containing early traditions of the Semitic race, and endeavoured to parry the conclusions of logic by an appeal to what transcends logic, therefore it became the fashion to treat this kind of evidence as entirely illegitimate, to evade conclusions derived from the fact that, in widely separated areas, a common tradition of a common catastrophe of some kind had survived the disintegrating influences of time, and to argue as if this was utterly worthless evidence, and to be thrust aside entirely in favour of empirical testimony. As a good friend of mine, well known to your readers, said to me, "If I cleave a boulder and find a fish with every detail preserved in its midst, I call that evidence." The other, he strongly implied, is mere dreaming. It is time a more judicial attitude was adopted towards this kind of evidence, and we purpose quoting it in what follows. Let us, however, to our task. What then was the proximal cause of the Extinction of the Mammoth? The first piece of evidence we shall quote is of a singularly direct kind, and we owe it to the ingenious and experienced skill of Professor Brandt. His observations are so interesting and important that they should be quoted in the original words. He says: "Bei der genauen Untersuchung des Kopfes des *Rhinoceros tich.* vom Wilui war ferner auffallend, dass die aufgefundenen Blutgefässe, die aus seinem innern genommen wurden, bis zu den Capillargefässen mit brauner Masse (Blutgerinnsel) augefüllt erschienen, die an manchen Stellen noch die rothe Blutfarbe zeigte. Ich konnte bei der Wahrnehmung der so stark mit Resten der Blutkügelchen angefüllten Kopfgefässe den Gedanken nicht unterdrücken, das das Individuum, dem sie angehörten durch die vermuthlich während des Ersäufens entstandene Asphyxie sein Lebensende gefunden haben dürfte" (Proceedings of the Berlin Academy, 1846, page 223).

These very interesting observations of a most careful and competent observer, that the Rhinoceros of the Vilui came by its end by being suffocated or drowned in mud, is a good introduction to the chain of evidence pointing the same moral which I shall presently cite. Brandt, in the paper just quoted, tells us that, in conjunction with Hedenstrom, he made a careful microscopic examination of the earth which was attached to these Rhinoceros remains, and found them to consist of two kinds, the most important being mould containing vegetable fragments, and which he took for remains of fresh-water plants, and the soil as a fresh-water deposit. The other kind consisted of a blue-grey iron sand (*id.* 224).

Brandt quotes this discovery of vegetable debris in the soil attached to the head of the Rhinoceros in proof of his position, which he argues for elsewhere, and which has been a favourite one with some English geologists, that the Mammoths, etc., were suffocated in the river mud which eventually covered them up entirely. To this theory, however, there is more than one fatal objection. In the first place, as we have seen, the large majority of the remains are not found in the river-beds, but in the high hillocks of the tundra, out of reach of the rivers. Again, Brandt's reasoning, that the bodies were covered by successive deposits of the river mud, is inconsistent with their perfect preservation, which necessitates their having been engulphed at once and for ever. Lastly, and most important of all, there is no mud brought down by the rivers in which they could sink in this way. Schmidt, an excellent geologist, who especially addressed himself to this point, says expressly: "Die Nordischen Flüsse werfen keine grossen Mengen von Schlamm aus; die dünnen Schlammschichten, die nach dem Frühlingshochwasser auf den Niederungen am Flussufer zurückbleiben, können kein Mammuth versinken lassen" (Bulletin St. Petersburgh Academy, 13, 119).

Since writing the former papers of this series, I have read L. von Schrenck's most interesting memoir on the discovery of a carcase of the *Rhinoceros Merckii* (the *Rhinoceros leptorhinus* of western authors) in Siberia. A few words about this discovery will not be out of place here. This carcase was found in 1877, and was first described in an article by M. Czersky, in the Memoirs of the East Siberian branch of the Imperial Bureau of the Geographical Society, who mentioned the arrival of the head at Irkutsk, and assigned it to the ordinary Siberian Rhinoceros, the *Rhinoceros tichorhinus*. The body was discovered on the river Balantai or Butantai, as Schrenck would read the name, a feeder of the Yana, about 200 versts to the north of Werkhoyansk. This district is perhaps the very coldest in all Siberia. The head and one foot of the Rhinoceros were cut off and sent to Irkutsk by a merchant named Gorokhof, while we are told the body was washed away by the river and lost. The head was eventually sent on to Moscow, and has been described in detail by Schrenck in a paper read on the 17th of December, 1879, before the Imperial Academy, and published in the 17th volume of its Memoirs, with most interesting photographs of the head in question, and of that from the river Vilui long ago described by Pallas.

It is no part of the present paper to refer to the elaborate criticism by which Schrenck fixes the specific character of the animal, nor yet to discuss his somewhat fantastic notion that it and its companions came by their end by being suffocated in snow-drifts, a view which cannot be reconciled with the many facts mentioned in these papers. One passage in the memoir is, however, of singular interest to us, and may be quoted in conjunction with that already cited from Brandt. Speaking of the nostrils, Schrenck says: "Die Nasenlöcher an demselben sind weit geöffnet und ueber dem unbeschädigten rechten zieht sich eine wohl damit zusammenhängende Reihe horizontaler Falten hin. Auch der Mund steht zum Theil offen. Man möchte daraus schliessen, dass das Thier durch Erstickung verendete und zuvor noch durch Aufreissen der Nasenlöcher dem Tode zu entgehen suchte" (*op. cit.* pp. 48–49).

This sentence confirms the statement of Brandt, and we may take it that the Rhinoceros in each case was suffocated or drowned. The postulate about the snow-drift may be set aside as quite untenable. It necessitates not only that the snow-drift should have existed at the time when the Rhinoceros lived in Siberia, but have remained intact with its contents ever since; but, as we know from many other cases, these carcases are not found in frozen snow or ice above the level of the ground, but in frozen earth, and buried several feet below it. Postulating then that the great Mammals were destroyed in some violent way implying suffocation or drowning, let us proceed.

A theory of their destruction, which has been urged by some writers, has many adherents. It is that the animals sank in boggy ground, and were thus overwhelmed; but this also, as in the case of the theory about the river mud, is incompatible with the evidence. They are not generally found in boggy ground, nor in ground that could ever have been boggy, but in layers of clay and sand raised in conspicuous hillocks above the surrounding tundras. As is our wont, we have tried to exhaust the various possibilities of the situation, and it seems to us there is only one alternative left. If the animals died suddenly by drowning, and there was a sudden change of climate immediately afterwards, it seems to follow that they came by their end by some catastrophe by which they were swept away together with the sand and clay in which they are now enveloped, and that this catastrophe, as the older writers urged, was in the nature of a wide-spread flood of water, which covered the carcases immediately with a thick layer of deposit, and buried them out of the reach of the weather and other vicissitudes. This accounts, as no other theory does, for the remains occurring so abundantly in the high ground forming the water-shed between the various rivers that flow northwards. It accounts also for their sometimes being found intact, and sometimes disintegrated. It accounts again, as no other theory does, for the discovery of considerable quantities of drifted branches of trees in close neighbourhood with the examples of the Mammoth found by Middendorf on the Taimyr—that discovered in digging the canal at Bromberg, which I described in a previous paper, where the skeleton was found among a number of trunks of birch trees, "Sceleton in sylva prostrata inventum esse, et quidem inter arbores," as Brandt describes it, and accounts also for the peculiar contorted attitude of one of the two skeletons discovered at Torma, and described by Cuvier as being in a cramped and curved position, occupying a space twenty feet in length, with its hind feet near its tusks (Oss. Foss. vol. ii. p. 85).

We take it further that, if we are to interpret the past rigidly by the present, and invoke only such causes as operate now, it will be difficult to account for the immense deposits of bones which occur together. Travellers who have visited the ordinary haunts of the Elephant and Rhinoceros have frequently remarked on the extraordinary scarcity of their bones and other remains. When old and worn out, they apparently seek out the recesses of the forest and retire there to die. Here, on the contrary, we have remains of whole herds together; the bones equally preserved, the ivory equally fresh, and pointing to but one conclusion, that they perished in herds where they are found, and perished by some overwhelming cataclysm. The fact of so many of the remains being found in high ground seems to show that this high ground was a place of refuge where the beasts congregated in the presence of some common danger, such as a general inundation which threatened to annihilate them. In this way also we can best account for the heterogeneous character of the collections of bones, Mammoth and Rhinoceros, Bison and Bos Primigenius, Musk Sheep and Stag, etc., animals that do not naturally herd together, which cannot be supposed to have visited one particular bog at one time in their usual course of life to be engulphed, and would not perish from such a cause in vast herds of many hundreds together, as they must have done in New Siberia, on the Obi, at Canstadt, etc. It has been suggested that this mixture of species is to be explained on the theory that where it occurs there was once a crossing place or ford across a river, where it is natural that accidents on a large scale should happen, but this will not apply at all to Siberia, where so many of the deposits are not found near rivers, and where the main deposits, such as those of New Siberia and the adjacent islands, are not only 150 miles distant from the mainland, but out of the way of any river current. It seems clear to me that this gathering together of the varied fauna of the district is paralleled by the great floods which occur occasionally in the tropics, where we find the tiger and his victims, all collected together on some dry place reduced to a common condition of timidity and helplessness by some flood which has overwhelmed the flat country.

Whichever way, in fact, we view the problem as a zoological one, we are forced to the same conclusion, namely, that the Mammoth perished by a sudden cataclysm, in which he was overwhelmed by a wide-spread inundation. Let us now turn to the geological evidence proper. Limiting ourselves at present to Siberia, where, as we have seen, the problem may be studied with fewer sophisticating surroundings, I will first quote Pallas, who, although his views are crude in some respects, was a first-rate observer, and one to whom Natural Science has hardly done sufficient homage. He, of course, postulates, as do his contemporaries, that the Rhinoceros and Elephant lived in the south, and was carried north by violent means. His words, speaking of the Rhinoceros of the river Vilui, are: "Itaque tantum hoc videtur stupendum quomodo Rhinocerotis in Australionibus terris Asiae nati cadaver integrum tanta vehementia atque celeritate per tot mille stadia in arcticas terras transvectum, ibique arena obrutum et conglaciatum fuerit, ut putrefactione partes molles interea non diffluxerint. *Itaque catastrophes tremendae, integrique forte Pelagi Asiam ab Austro ad Boream violentissime transfluentis argumentum probet Rhinocerotis,*" etc. (Nov. Comm. St. Peter. Acad., 1773, vol. xvii. p. 594). Again, "Si recensitis hucusque observationibus addas magnam copiam ossium Elephanti aliaque exotica crania a Samojedis colligi venumque Beresovam adportari e planitie, quam colunt, vastissima, sylvis denudata, Sibiriaque borealem oram usque in latitudinem sexaginta octo circiter graduum constituentis *hanc ipsam vero planitiem monumenta plurima inundantis Pelagi servare* . . . Tum quidem fateor, contra opiniones in hac re caeteras omnes maxime verosimile videri ossa subterranea quadrupedum in Australibus terris natorum que nunc per borealem Asiam sparsa jacent, reliquias esse cadaverum ex australi patria in arcticas usque plagas abreptorum *et gravissima forte olim globi terraquei catastrophe submersorum. Eamque non solum vere exstitisse sed etiam nolentissimam atque subitaneam fuisse novo atque inaudito argumento probabile reddam*" (*id.* pp. 584–5).

We will now turn to Erman, a first-rate observer, who has the following remarks: "The ground at Yakutsk . . . consists, to the depth of at least 100 feet, of strata of loam, pure sand, and magnetic sand. They have been deposited from waters *which at one time, and it may be presumed suddenly, overflowed the whole country as far as the Polar Sea.* In these deepest strata are found twigs, rocks, and leaves of trees of the birch and willow kinds; and even the most unbiassed observers would at once explain this condition of the soil by comparing it to the annual formation of new banks and islands by the floods of the Lena at the present time; for these consist of similar muddy deposits and the spoils of willow banks, but they lie about 110 feet higher than the ground which was covered by those ancient floods. Everywhere throughout these immense alluvial deposits are now lying the bones of antediluvian quadrupeds along with vegetable remains" (*op. cit.* ii. 378). After the passage about the hoards of birch trees under the tundras and in New Siberia, which I quoted in a previous paper (GEOL. MAG., Decade II. Vol. VII. pp. 559–560), Erman goes on to say: "It is only in the lower strata of the New Siberian wood-hills that the trunks have that position which they would assume in swimming or sinking undisturbed. On the summit of the hills they lie flung upon one another in the wildest disorder, forced upright in spite of gravitation, and with their tops broken off or crushed as if they had been thrown with great violence from the south on a bank, and there heaped up. Now a smooth sea covering the tops of these hills on the islands, would, even with the present form of the interjacent ground, extend to Yakutsk, which is but 270 feet above the sea. But before the latest deposits of mud and sand had settled down, and had raised the ground more than 100 feet, the surface of such a sea as we have supposed would have reached much further up, even to the cliffs in the valley of the Lena. *So it is clear that at the time when the elephants and trunks of trees were heaped up together, one flood extended from the centre of the continent to the furthest barrier existing in the sea as it now is.* That flood may have poured down from the high mountains through the rocky valleys, The animals and trees which it carried off from above could sink but slowly in the muddy and rapid waves, but must have been thrown upon the older parts of Kotelnoi and New Siberia in the greatest number and with the greatest force, because these islands opposed the last bar to the diffusion of the waters" (*op. cit.* ii. pp. 379–380). Let us now turn to Murchison and his companions, who wrote the famous work on the Geology of the Urals.

In explaining the mode of occurrence of the Mammoth remains in the Urals, after postulating the former existence of lakes where the auriferous and Mammoth detritus now is, they say, "Granting these premises, all the relations of the Uralian Mammoth alluvia may, it appears to us, be rationally explained; *for in some of the most violent movements of elevation, which gave rise to the present central watershed, we may readily conceive how, their barrier being broken down, these lacustrine waters were poured off, and how their shingly bottoms and shores, already containing bones of Mammoths, were desiccated and raised up into the irregular mounds which now constitute the auriferous alluvia.* . . . . In some cases, however, the denuding and abrading power of waters, produced both by the bursting of lakes, and the change in the direction of the currents, must have been considerable, for such alone would account for several of the appearances we have spoken of, and the transport of large blocks and enormous pepites of gold into broad lateral depressions" (*op. cit.* pp. 492–3).

Again, a former terrestrial surface, on which the great quadrupeds lived for ages, *and the rupture and desiccation of adjacent lakes, coincident with some of the last elevations of the chain*, will, we are convinced, best explain the condition in which the remains of the Mammoths are left buried on the edges of the uplifted ridges of the Ural, as well as in the low lands and great estuaries furthest removed from them. In the depressions at the very foot of the chain, the Mammoth skeletons are broken up, and their bones, together with those of *Rhinoceros tichorhinus* and *Bos urus*, are rudely commingled in the coarse shingle derived from the mountains, or in the clay above it. In proportion, however, as we advance into the plains of Siberia, or descend into the valley of the Tobol and the Obi or their affluents, these bones increase in quantity, and are at the same time in much better conservation" (*id.* 494).

"The single fact of the very wide diffusion of Mammoth bones over the surface of such enormous regions of the earth would in itself lead us to believe, that those creatures had really been long inhabitants of such countries, living and dying there for ages, *while their final destruction may have resulted from aqueous debacles dependent on oscillations of the land, the elevation of ridges, and the formation of much local detritus*" (Russia and the Ural Mountains, vol. i. p. 495). Speaking of the herds of Mammoths that must have lived in the Northern Urals, the same writers say: "Such might we add, have been the position and condition of some of these creatures at the periods when, as we have imagined, the highest ridges of the Ural were thrown up, followed by the rupture of many lakes, *and the consequent inundation of large tracts of the flat country, previously frequented by these great herbivorous animals*" (*id.* 498).

This completes our survey of the Siberian evidence, and I take it that not only is it everywhere consistent with the conclusion of this paper, namely, that the Mammoth was finally extinguished by a sudden catastrophe, involving a great diluvial movement over all Northern Asia, and accompanied by an equally sudden and violent change of climate, but that it is consistent with no other conclusion. We are now in a position to follow up the problem as it presents itself in Europe, where, as we said, many subsidiary difficulties make the discussion of the main question a complicated one. It is clear that these difficulties must be frankly faced if our theory is to remain good, and I propose to examine them in another paper, where I hope to show that, in Europe as in Siberia, the evidence points overwhelmingly to the same conclusion.

IV.—The Ashburton Limestone: its Age and Relations.

By A. Champernowne, M.A., F.G.S.

It has been for some time a matter of surprise to me that Dr. Holl, in his exhaustive memoir "On the Rocks of S. Devon and East Cornwall,"—after once raising the question "whether the limestones" (those of our present subject) "might or might not be the same as those of Ogwell, Ipplepen, and Dartington thrown over a broad anticlinal axis of the lower slates to the North-West,"[1]—should have ceased following out that line of thought to what appears to me the only possible issue, since he thoroughly recognized the existence of uniclinal structures in parts of the district.

It may be as well to say at once that I do not believe these limestones to be on a lower horizon than those of Ogwell, Ipplepen, and Dartington, all appearances to the contrary notwithstanding; and I will proceed to give a summary of my reasons for holding so pronounced an opinion, to which, let me add, I have always more or less inclined.

That the direct evidence is, as Dr. Holl says, against it, I grant; yet not "entirely" so, for, as he himself admits, "palæontological records would not altogether discountenance it."[2] This, as far as

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[1] Q.J.G.S. 1868, p. 442.

[2] *l.c.* p. 443.

it goes, is certainly direct evidence, but we shall see that there is abundant *indirect* evidence, tending to show that they are one and the same.

Mr. Godwin-Austen did not, as far as I am aware, ever hint at these limestones having a uniclinal structure, but I am not familiar with his earlier papers, though quite so with that in the Trans. Geol. Soc. 2nd series, vol. vi. In the latter the Ashburton limestone is distinctly referred to as a "lower limestone."[1]

As regards the lithological varieties to be met with in this range of limestones, we need not dwell at any length. Suffice it to say that it is usually well-bedded and dark-coloured; occasionally dolomitized but not extensively so, like the Dainton mass and others which are crystalline and run into light colours; but that in other respects it may be paralleled with almost any of the limestones of South-East Devon or Plymouth. Moreover, it is quite possible that the highest beds, which at Dartington and elsewhere are the dolomitized portions, may be seldom seen, that is, of course, provided the uni-synclinal folding can be proved. But be this as it may, dolomitization is always very impersistent, and the causes of its phenomena still very enigmatical.

We now come to the fossils; the collector will be sadly disappointed in these limestones. I know of no spot where fossils can be extracted from the matrix, but the records can be fairly well read in the polished slabs of Ashburton marble, on the large sawn blocks in the quarry. Large *Stromatoporæ* of the same kind as those which characterize the Ogwell, Dartington, etc., limestones, are very abundant, two may be cited—one of loosely reticulated and open structure (query, not named or var. of *S. polymorpha*, Goldf.)—another of remarkably fine structure, which, with my kind friend Dr. Carter, I regard as belonging to the same section, or identical with *S. typica*, Rosen, the concentric layers "having the form of rhombs, triangles and pentagons,"[2] thus simulating, though lacking the geometrical constancy of the *Hexactinellidæ.*

Interspersed with these we frequently observe fragmentary sections of *Stringocephalus*, shells which, whether from the large septum projecting from the concave side, or from the punctate shell-structure, are not readily mistaken. Other Brachiopod sections, with striæ, betoken *Uncites*. Some portions of beds are full of *Gasteropoda*, among which the outlines of *Murchisonia* can be detected. Others again are made up wholly of the so-called *Caunopora ramosa*, Phillips, which is also common in the Lemon Valley S.W. of Bickington, as well as in the Ogwell and Bishopsteignton beds. It abounds also in the Westphalian limestone, and at Paffrath. *Amplexus tortuosus*, Phillips, simple *Cyathophylla*, apparently few as to species, *Cystiphyllum vesiculosum*, Goldf., *Favosites* (sp.), *Aulopora repens*, Goldf., can all be observed, and probably other forms might be added to this small but significant list, which links the Ashburton limestone with that of Schwelm, Elberfeld, etc.

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[1] See also De la Beche, Geol. Report, p. 69.

[2] Rosen, "Ueber die Natur der Stromatoporen," p. 17 and woodcut.

The Chudleigh limestone has been classed as a lower limestone together with the Ashburton band by Mr. Godwin-Austen, and indeed looking at their strike on the map, no one would reasonably doubt their belonging to the same run of beds, both being more or less closely skirted along their North-West side by a downcast area of Culm-measures.[1]

The Chudleigh band is, to say the least, closely connected by its fossils with that of Ogwell. In addition to the rich Gasteropod fauna of Lower Uppercot and Kerswell quarries (of which a list was given in Mr. Reid's paper, Geol. Mag. 1877, p. 455), Mr. Vicary, F.G.S., has shown me in his splendid collection two specimens of *Uncites gryphus*, Defr., and two or three perfect valves of, I believe, *Megalodon carinatum*, Schlottheim.

But if any doubt lately existed as to whether the Chudleigh band is identical with the Ogwell beds, or lower, we may regard it as now set at rest. Prof. Roemer (Geol. Mag. 1880) assures us that the thin red limestone beds of Lower Dunscombe, near Chudleigh, abounding in Cephalopoda, are the *Gon. intumescens* stage, having the same relations as in Germany, namely, at the summit of the Eiflerkalk, which accordingly must be represented by the Chudleigh, no less than by the Ogwell beds.[2] But the Chudleigh band is admitted to be the continuation of the Ashburton band, therefore we must logically concede the same identity between the Ogwell and Ashburton beds.

But why need we feel staggered at the uniclinal structure involved in this identification, merely because, in two or three instances, the angle of inversion is so great that the beds lie at 20° or even 15° to the horizon, as mentioned by Dr. Holl? This folding is in fact but the natural continuation, with partial flattening of the axes and widening of the area, of a great series of folds which pass North of the Plymouth limestone and round the granite by Ivybridge and Ugborough with some vertical dips, as clearly shown by Dr. Holl's section.[3]

In the large quarry at Dean the dip is 35° towards E. 5° N. Near Buckfastleigh some dips of 20° or under occur, and once more at Chewley, S. of Ashburton. Beyond this towards the North-East the dips again become high. From the town to Goodstone they are nowhere under 45°, *along inverted margin.* The line as laid down by De la Beche needs but the most trifling alteration. Just a mile N.E. of the town, along the road that follows the boundary, two adjoining quarries show a steady dip of 50° S.E., and if from this point we cross the outcrop (one field to the turnpike road), on the other side we come first upon a disused quarry, beds dipping 30°, and then the great Ashburton marble quarry, where the dip is steady at 25° S.E., *half the first angle.* It seems the most reasonable inference that these planes meet at no great depth; in other words that the limestone is doubled upon itself. From the road on the inverted margin, 156

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[1] Vide paper by the author, Geol. Mag. 1880, last par. p. 361.

[2] The *Gon. intumescens* stage is classed by the German geologists as the commencement of the Upper Devonian.

[3] *l.c.* p. 438.

paces takes us to the furthest limestone face, which distance at 50° gives a thickness of more than 300 feet (354, if yards were paced, and I cannot estimate it at much less). Between this and the turnpike road, along the level ground, we must presume the axis of syncline passes. The Rew Mill fault, dying out at this point as shown by De la Beche, probably exercises little or no effect on the limestone dips.

There are other interesting facts connected with these limestones, but none more so than the apparent gaps in its continuity. For instance, after the first railway cutting South of Ashburton station there is no limestone until we reach the Pridhamsleigh fault: it is abruptly lost for $\frac{3}{4}$ of a mile. This is caused by an East and West fault passing Chewley and Summer Hill, and meeting the Pridhamsleigh fault at an angle of about 40°. These two heave the wedge of country between them and "throw out" the limestone fold. The evidence is clear; for the mass of igneous rock constituting Pear Tree hill is shifted towards the East and laid open in the railway cutting (9th milepost from Totnes) dipping about 35° towards E. 25° S., the intervening ground towards the station being low and swampy where the fault passes.[1] The rocks immediately S.E. of the town appear identical with those on the N.W., the limestone being troughed in them.

A similar gap occurs immediately S.W. of Buckfastleigh, between that place and the Dean limestone; but, interesting as the structure is, present space will not admit of an attempt to describe it, more than to say that the Dean band is evidently thrown down by a fault on the north, which is metalliferous, having been once worked as an iron mine.

In the country to the East and South-East of the whole belt, taking Woodland as a centre between the Dart and the Lemon, the igneous rocks, ash-beds and lavas, rather than the "greenstones," will help to unravel whatever may be obscure in the structure; my maps already begin to foreshadow the appearance, but we must remember that, igneous rocks excepted, we have to deal with an almost purely argillaceous series, and that there is little at first sight to dispel the illusion of an ascending series from the Ashburton to the Ipplepen, etc., limestones.

It is necessary however to point out that, at a certain distance from the South-east of the limestone band, there runs a belt of coloured slates, purple and greenish, which have an important bearing on the structure. They appear about a mile East of Buckfastleigh, very narrow at first, but beyond the Pridhamsleigh fault, in the upcast country about Penrecca slate quarry, are more striking; they can be traced continuously towards the North-east, only affected by N.W. and S.E. faults which equally shift all the rocks, and they curve round with the strike near Knighton and by Knowle Hill, reappearing on the opposite side of the Teign, where they are exposed in the railway cutting near Combe cellars.

Intrusive rocks, individually of small extent, break out along their

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[1] This shifted continuation of the Pear Tree rock is omitted on the map.

line, and for a short distance from the contact, the colour is gone from the slates. Instances of this can be seen conspicuously in a quarry at the Northern foot of Knowle hill near Newton Abbott, and again in the cutting near Combe cellars, where one or two small tongues a few feet thick appear isolated in the discoloured slates which surround them. They are probably only branches from the great mass that runs up to Rowdon Cross.

Thus we see that these coloured slates which run S.E. of the Ashburton limestone pass North of the Ogwell mass, and South of that of Bishopsteignton, throwing them off on opposite sides. They form the crest of a denuded and overturned anticlinal line, and clearly correspond with the coloured slates North of Plymouth, at Mutley, etc., to which district we must now turn our attention.

The apparent thickness of slaty rocks North of Plymouth is enormous. An excellent paper "On the Geology of Plymouth" was written by Mr. Worth, F.G.S., for the Trans. Plymouth Institution, 1875. In that paper (p. 9) he pointed out that three or four sub-parallel belts of coloured slates, separated by slates of the ordinary type, are doubtless only one group, repeated by folds, the same general dips to the south at high angles prevailing throughout, making the apparent thickness vastly greater than the actual. Having formerly stayed some months at Knackersknowle, I can testify to the truth of these statements. The folds, however, are certainly more numerous than in the corresponding South-East Devon area, and the purple slates, their axes less thrown over, rise in greater bulk.

Dr. Holl has shown how, through a series of folds, the Liskeard and St. Cleer igneous rocks are brought down to Saltash,[1] and Mr. Worth has pointed out how close the igneous bands come down to the outcrop of the limestone at Devonport;[2] so that one may now confidently predict that the so-called "Liskeard and Ashburton group" of Sedgwick and Murchison will resolve itself into a complicated series of folds of the "Plymouth and Torquay group," limestone becoming scarce North-west from Plymouth, or possibly not being "brought in" among the folds. But at any rate such fossils as occur in this direction, especially at Liskeard, have been shown by Dr. Holl to be of a Middle Devonian type;[3] there is, in fact, no sign of a Lower Devonian or Coblentzian fauna or rock group in the neighbourhood of Liskeard, whatever the beds of the Looe river section, or those of Whitesand Bay, may be.

In contrast to this let us compare, first, a small tract comprising strata known to be of Lower Devonian age,[4] the Torquay Promontory, with, secondly, the slate rocks expanded West of the great limestones of Ipplepen, etc. In the former (saving some calcareous shales with lower Eifel *Orthides*, *Phacops latifrons*, *Spirifera speciosa*, etc., which peep out from under greatly faulted limestone in parallel stratification), we have a series of tough grey and brownish grauwacke grits and schistose beds with fossils of the Coblentzian series,

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[1] *l.c.* p. 442.
[2] *l.c.* p. 7.
[3] *l.c.* table iii. p. 450.
[4] Murchison, Siluria, p. 398; Salter, Q.J.G.S. 1863, p. 483.

passing up into a group of quartzose grits red and greyish, interstratified with purplish and variegated sandy shales—the *Lincombe and Warberry grits*[1]—with some fossils differing from the Meadfoot beds, notably spined *Homalonoti*. Moreover, we have a mass of rocks from which it may be safely asserted that not a decent roofing-slate could be obtained.

In the latter, namely, the slaty district of Staverton, Woodland, etc., several slate quarries are worked, and there is apparently an utter absence of grit bands—I know of none. In fact the difference is, to my mind, so complete as to lead to the conclusion that, from the West of the Ogwell, Ipplepen, and Dartington limestones to the extreme North of the county, the Torquay grits nowhere reappear at the surface.

This formerly presented a difficulty to my mind, at least whilst acquiescing in a downward sequence from the Ogwell limestone to the Culm-measure fault; but after having convinced myself that the Ashburton is identical with the Ogwell limestone, and consequently that this downward sequence is illusory, and further, that the Lower Devonian is on all sides *faulted through* the Torquay limestones, the difficulty has disappeared.

A suite of fossils, collected from several slaty localities West and South-west of Totnes, to which I hope some day to draw attention, will go far towards confirming the view that a large portion of the South Devon slates must be classed as Middle Devonian with the limestones, which they both laterally replace by interdigitation, and also partially underlie. In particular the slates of Englebourne Quarry near Harbertonford at once recall the Wissenbach slates, with which to some extent the organic remains also correspond.

It is worthy of remark, as distinctly bearing upon this subject, that M. Dewalque, speaking of certain tints employed by H. von Dechen, especially for the slates of Wissenbach, observes parenthetically that there is a general consent now-a-days to regard them as the local equivalent of the limestone of Givet (Eifler Kalk).[2] The writer then mentions the Lenne schists as having a special tint. If we draw a line due South from Elberfeld to Bensberg, across these schists, we find nothing to support the notion of a *lower* reef limestone; on the contrary the Paffrath and Refrath series, as prolific as any Middle Devonian succession, hold a position analogous to that of the Ashburton limestone, the older beds resting on the younger, a fact which greatly strengthens the views advocated in this paper.[3]

When we reflect that all the rocks of our peninsula are but a link in a system of plications that extend through South Ireland, under the South-Eastern Counties, through Belgium, the Rhine Province and the Hartz; and on the one hand, at Killarney, we have the

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[1] These must not be confounded with the purple sandstones and slates of Cockington, Ockham, Beacon Hill, Windmill Hill, Southdown Cliff, etc., etc., which are of Upper Devonian age, doubtless the equivalents of the Pickwell Down sandstones of North Devon.

[2] Prodrome d'une description géologique de la Belgique, 1880, p. 114.

[3] Murchison and Sedgwick, Trans. Geol. Soc. 2nd series, vol. vi. pp. 241—244.

Carboniferous Limestone thrown under the Glengariff Grits, then the Coal-measures under the Carboniferous Limestone of the Mendips, and Eastward Dumont's well-proved Belgian inversions, etc., our present subject assumes but a very subordinate place in so grand a system.

Such sound generalizations as a "contracting crust" with "lateral displacement" through "tangential thrust," now happily rank as part of the common stock of knowledge. No writing has tended to bring this about in a greater degree than Prof. Heim's magnificent work "On the Mechanism of the Formation of Mountains, and Monograph of the Tödi-Windgälle group," embodying the grand discoveries of Escher von der Linth.

Fortified by such established facts, we feel unfettered in identifying distant out-crops from the sum of their characters, palæontological, etc., a *vera causa* being recognized for their appearance in positions the most startling at first sight.

I cherish the hope of being yet able to publish a geological map of this Calciferous district, including portions of Sheets 22 to 25 of the One-inch Survey, having spared no pains to lay down the lines as correctly as the imperfect topography and half-worn-out engraving of the old maps will admit of.

Note.—This seems a fitting opportunity, since several igneous rocks have been referred to, for saying that Mr. Rutley, of the Geological Survey, has kindly examined and given me a written opinion on many slices of South Devon rocks, which have been cut for me by Mr. Cuttell. They are chiefly from the important lavas of Upper South Devon (Upper Devonian) age that run East and West through Totnes and the adjoining parishes of Harberton, Ashprington, Cornworthy, etc. Whilst hoping to do justice to them in their proper place, I will only now observe (being quite a tyro at the polariscope myself) that there is the strongest concurrence between the verdicts given and the aspect of the rocks in the field.

V.—ON THE ABSENCE OF JOINT-STRUCTURE AT GREAT DEPTHS, AND ITS RELATIONS TO THE FORMS OF COARSELY CRYSTALLINE ERUPTIVE MASSES.

By W. O. CROSBY, of Boston, Mass., U.S.A.

"IT is often said by vein-miners who have worked at great depths, that the jointed structure of rocks fades away and disappears in the deeper parts of the mines. This, however, is probably a case of the rule 'de non apparentibus et non existentibus eadem est ratio.' All the joints near the surface are more or less acted on by the weather. The deeper-seated rocks may be just as much traversed by joints, but they are merely mathematical planes of division, the faces of the blocks adhering as closely as if they did not exist till the weather makes them apparent, or some force tears the blocks asunder."

This extract from Jukes and Geikie's Manual of Geology[1] is

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[1] Third edition, p. 184.

undoubtedly a correct expression of the prevailing opinion among geologists concerning the lower limit of the joint-structure. A joint, of course, is always a plane of division, not a theoretical or potential plane, as in crystalline cleavage, but an actual physical break, of which the quarry man and miner consciously or unconsciously take advantage. And the joint must be almost equally a source of weakness in the rock, whether it exists as an open crack near the surface, or as a merely mathematical plane at greater depths. Now it seems probable that the miner judges of the persistence or non-persistence of the joint-structure in depth, not so much by the presence or absence of visible planes of division, as by the ease with which the rock is broken and removed. If this is so, then it is clear that the criticism embodied in the foregoing quotation from a standard authority fails to cover the point; and the relation of jointing to depth must be regarded as an open question still.

Geologists are generally agreed that the two principal causes of joint-structure are contraction of the rocks and movement of the rocks; and the contraction, speaking generally, must be ascribed either to the consolidation of sedimentary rocks, the cooling of eruptive rocks, or the crystallization of rocks of either class.

The notion generally held by geologists that the jointing continues downward indefinitely, perhaps as far as the rocks are solid, may be sound enough when only the joints due to movements of the rocks are considered, but when we take into account the more general and efficient cause of jointing—contraction—this view seems to rest on no better foundation than the supposed fact that no scientific observation or theory points to the contrary conclusion. My present purpose, however, is to show that, even if we reject, as untrustworthy in this instance, the testimony of the miners, there is still good ground for believing that, in the stratified rocks at least, the joint-structure due to contraction is to a very large extent a superficial phenomenon.

Taking a general view of the deposition of the stratified rocks, let us trace the history of a single stratum, and observe where and when the joint-structure arising from contraction is probably first developed in it. As the process of deposition goes on over the area, this stratum is gradually compacted by the increasing pressure of newer deposits, and we get contraction in the vertical direction; but I think too much stress cannot be laid upon the fact that a vertical pressure, acting directly, must be entirely inoperative so far as the development of joint-structure is concerned, since this demands lateral contraction. However, as the pressure imposed upon the stratum by later sediments increases, so does the temperature, through the rising of the isogeotherms; and this higher temperature, co-operating with the pressure, effects the expulsion of a portion of the water with which the material was originally saturated. The loss of water from the stratum means, of course, a tendency to contract in all directions; though still chiefly in the vertical direction, owing to the controlling influence of gravity. Thus it appears that only a modicum of the contraction which the rock experiences during its consolidation and burial under newer formations is in the horizontal direction, in which alone it can result in the formation of joints.

But does this lateral contraction actually occur? This seems at least doubtful; for the increase in temperature, which for a reasonable depth—say 10,000 feet—must be considerable—probably 200° F., means a tendency to expansion. The contraction of the rocks resulting in the formation of joints is, of course, measured by the volume of the joint-cracks, when they have not been widened by atmospheric action, etc., and are really contraction and not movement joints. Now the volume of the joint-cracks will not probably in ordinary rocks amount to more than a small fraction of one per cent. of the volume of the rock. But, according to Colonel Totten's experiments, the moderate increase of temperature supposed above would produce an expansion of about ·001 in marble, and ·002 in sandstone; enough, probably, to close up all the joints in each of these rocks, *i.e.* to counteract the tendency to lateral contraction.

At greater depths than 10,000 feet the influence of heat in opposing the contraction of the rocks would be still more marked, for while the temperature and pressure both probably increase at a sensibly uniform rate for at least ten or twenty miles below the surface, and the rate of expansion may be assumed as sensibly the same for a range of temperature of 1000° or more, yet the tendency of the rocks to contract through either compression or loss of water must diminish rapidly.

According to the argument here presented, then, it is possible that sediments may be carried down to any depth in the earth's crust, and attain any degree of consolidation, without becoming jointed. It will be claimed (and admitted), however, that a net contraction must take place sooner or later; for this is required by the universal jointing of the rocks at the surface. But when and where will this occur.

Suppose that our sea-floor becomes dry land—is changed from an area of deposition to one of erosion, then during the lapse of ages the particular stratum which we are following is gradually brought back toward the surface. The isogeotherms fall and its temperature is lowered, and at the same time the pressure of the superincumbent beds is removed. The cooling necessarily implies contraction; but the removal of pressure is not necessarily followed by expansion, because the sediments, while subjected to pressure, and largely as a result of the pressure, have become consolidated; and if they are compared to a compressed spring, it should be to a spring which has received a permanent set.

In other words, as the deeply buried stratum gradually nears the surface, through erosion, it for the first time actually experiences contraction in all directions and becomes jointed; and this is the direct result, not of pressure or desiccation, but of cooling. The cooling, contraction and jointing are proportional to, and keep pace with, the erosion. Hence it follows from this way of regarding the subject that contraction-joints have their best development at the surface, gradually dying out at considerable depths, but constantly growing downwards as the surface is lowered by denudation.

This argument for the essentially superficial nature of joint-structure, derived from considerations touching upon its origin, is, in itself, perhaps, too speculative to carry conviction to many minds; but I feel that this criticism will not lie with equal force against the argument based upon the relations of the jointing of the rocks to the forms of eruptive masses, which I now proceed to present.

There are few, if any, geologists who will question the truth of the proposition that, in general, other things being equal, the coarseness of the crystallization of eruptive rocks is proportional to the depth below the surface at which they have cooled and solidified; and consequently that we see coarsely crystalline eruptives exposed on the surface now only as the result of extensive erosion or faulting; so that, when these rocks are exposed by erosion, as in most cases, the mean size of the crystals becomes a rough measure of the amount of denudation which the region has suffered, and of the age of the intrusives.

It is also a fact, well known to most field-geologists at least, that the regularity of the outlines or boundaries of an intrusive mass is inversely proportional to the coarseness of its crystallization. To appreciate this point it is only necessary to compare the form of a typical mass of granite, or any granitic rock, with that of a typical mass of some fine-grained exotic, like ordinary basalt. The latter is straight and wall-like; while the former is thoroughly irregular, and penetrates the surrounding formations in many jagged spurs and branches.

In other words, and speaking generally, the coarsely crystalline eruptives, which have cooled at great depths, occupy extremely irregular cavities in the crust; while the seats of the finely crystalline eruptives, which have cooled near the surface, are well-defined, wall-like fissures, with parallel sides.

It goes almost without saying that the forms of the cavities and fissures filled by intrusives are determined very largely by the joint-structure of the enclosing rocks; and where these are well jointed, the avenues for the liquid rock are formed mainly by the simple widening of the joint-cracks. In proof of this it will suffice to cite the familiar fact that dykes, if formed of fine-grained rocks, generally conform closely in direction with the principal joint-planes of the intersected formation.

Now one of the most important and persistent characteristics of joint-structure, especially in stratified rocks, is its regularity and the really wonderful constancy in trend and dip of the joint-planes over extensive districts. Therefore, fissures produced in a well-jointed formation must, on the average, be far more regular than those arising in a portion of the crust where the joint-structure is wanting or is only imperfectly developed. The difference is precisely that between the fractures of highly cleavable minerals, like calcite or galenite, and of uncleavable minerals, like quartz.

Suppose, now, that we have a model of the earth's crust composed of a layer of quartz or glass below and a layer of calcite above, with a layer of some imperfectly cleavable mineral like felspar between; and suppose further that this is subjected to strains so as to produce transverse fractures. It is perfectly evident that the character of the miniature fissures thus formed will vary with the depth, being almost mathematically regular in the calcite, and very irregular in the quartz or glass.

But we know, by the outlines of the coarsely crystalline, *i.e.* the originally deep-seated, exotics, that the fractures produced at great depths in the earth's crust are highly irregular; and I believe that we find the best, if not the only, explanation of this well-established fact in the supposition that the actual structure of the crust is fairly represented by our imaginary model, the crystalline cleavage in the latter corresponding to the jointing of the former.

In other words, we know that fissures formed in the earth's crust are regular near the surface and irregular at considerable depths. The superficial regularity is clearly attributable to the joint-structure; while the greater irregularity in the deeper portions of the crust is a plain indication that the joint-structure fades away downwards. Certainly, in view of the marked influence of the jointing upon the forms of fissures near the surface, it is difficult, if not impossible, to conceive how the extremely irregular fractures produced nearer the source of eruptive rocks could have arisen in well-jointed formations.

It is important, however, in seeking an explanation of the extremely ragged outlines of many granitic masses, to recognize, besides the absence of jointing, the toughening effect of high temperatures, which produce incipient plasticity and cause the unjointed rock to tear rather than break.

VI.—HOW TO WORK IN THE ARCHÆAN ROCKS.

By C. CALLAWAY, M.A., D.Sc. (Lond.), F.G.S.

(*Concluded from* p. 353.)

THE *mineral composition* of rocks, often an important test in comparatively unfossiliferous formations, such as the Trias, becomes of supreme value amongst the Archæan groups. It is very frequently the *only* kind of evidence available, and, used with due caution, may lead to decisive results. In Anglesey, as illustrated in Fig. 1, and already described, it is nearly as conclusive as the testimony of organic remains; for the great similarity of the dark schist in two areas so near together renders their correlation in the very highest degree probable. The gneissic rocks of the Malvern Hills have been classed as Laurentian on the ground of the lithological resemblance between the two groups, though 3000 miles apart; and the determination has been generally accepted. But in such a case as this, high probability is all we can expect. Other gneissic and schistose systems have been described in America, though none of them so closely resemble the Malvern series as the Laurentian.

This test decreases in value as the formations compared increase in distance. Purple rocks, like the Wrekin lavas, are found about twelve miles to the west, in Pontsford Hill, and they may reasonably be referred to the same series. But the same high probability cannot be claimed for a certain purplish grit near Bangor, which in hand specimens can hardly be distinguished from some of the Wrekin tuffs. It is much more likely that the same conditions prevailed at the same time over an area of a few miles round the Wrekin than that they did so from the Wrekin to the Menai Straits. The very same volcanos might have poured forth both the Wrekin and the Pontsford Hill lavas, but it is less probable that volcanos were contemporaneously ejecting similar material in both the Wrekin and Bangor areas. Were the two formations compared separated by the breadth of the Atlantic Ocean, the probability would be still further weakened.

Several considerations must be taken into account in estimating the value of this test. It is first of all necessary to ascertain that the rock under investigation is *older than the Cambrian.* If this cannot be proved, the evidence is much weakened. The rocks of Charnwood Forest, for example, are overlain on all sides by strata none of which are older than the Carboniferous, so that all we can learn from superposition is that the Charnwood series is Pre-Carboniferous. Lithologically, the formation has affinities both with the Pebidian and with the Green Slates and Porphyries of the Lake District, supposed to be Ordovician. If the Charnwood group could be shown to be older than the Cambrian, the latter hypothesis would obviously be excluded, and the Pebidian age of the series would become almost certain. Even as it is, the mineral resemblances between these rocks and the Pebidian are so great that there is high probability of their contemporaneity. In Anglesey there is a great series[1] of slates, shales, breccias, and conglomerates, which much more closely resembles the St. Davids Pebidian than does the Charnwood groups. They are older than the Cambrian, for the Lower Cambrian contains pebbles derived from them. This narrows the evidence considerably. We are acquainted with only two or three Archæan groups in Britain, and as the Anglesey series is Archæan, and has no resemblance to any other group than the Pebidian, with which moreover its affinities are numerous and striking, the proof of its Pebidian age is almost complete. Lithological resemblance alone is not sufficient; Pre-Cambrian age alone is not sufficient, since there are several Pre-Cambrian groups; but the two combined form a fairly conclusive mass of evidence.

Another important accessory test is *similarity of succession.* The mineral resemblance between two groups of strata at some distance from each other, though often reasonably satisfactory proof of contemporaneity, is sometimes open to uncertainty, owing to the possibility of the resemblance being mere coincidence. The dark-green schist on the Menai Straits, in Anglesey, is, for example, undistinguishable from the dark schist (Fig. 1, *e*) of the central band.

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[1] Described in Quart. Journ. Geol. Soc., May, 1881.

But there is the bare possibility, though little probability, that the former is some other unknown group, since the strata of the two districts cannot be connected with each other, owing to an intervening faulted area. Further examination, however, removes the shadow of the doubt. Underlying the dark schist in the Menai band is a grey gneiss precisely similar to the beds (*d*), which pass under the green schist (*e*) in the central area. We have here, then, a resemblance not only of mineral composition and structure, but of succession. It is absolutely incredible that similar gneiss underlying similar schist in the two localities, which are only three miles apart, should be due to coincidence.

In comparing formations by their mineral characters, it is necessary to take them *as a whole.* To select specimens with a view to favour a preconceived theory will lead to no satisfactory result. Some examples will illustrate this point. Comparing the Archæan volcanic series of Shropshire with the Archæan volcanic series of Bangor, we find some striking resemblances. Some of the felspathic grits are almost undistinguishable in hand specimens; colour, texture, and constituents being the same. On the other hand, the differences are numerous. The lava flows of Bangor contain blebs and small crystals of quartz, and many of the grits and slaty beds are unlike in colour and composition. These dissimilarities are by no means fatal to the identity of the two groups, but they weaken the evidence in its favour. A second example occurs in the Scottish Highlands. One of the great unsettled questions of the day is the age of the newer gneiss series, which occupies the chief part of northern and western Scotland. Murchison claimed to have proved its Ordovician (Lower Silurian) age, but some others have asserted that it is simply the fundamental gneiss or Lewisian of the north-west coast brought up again in the centre and east of the Highlands. Those who hold the latter view maintain that the specimens which they have obtained from the Lewisian are closely similar to some of the eastern types. This may be quite true. Yet it is indisputable, as pointed out long since by Murchison and his followers, that, taken as a whole, the two rock-groups are widely dissimilar. The older gneiss is massive, intensely crystalline, and frequently hornblendic; while the younger is thin-bedded, not coarsely crystalline, and contains mica instead of hornblende. While, then, in this district it may be difficult here and there to assign a rock to its true place on lithological evidence alone, yet, studying the rock-masses on the large scale in the field, the differences between the two gneisses are broad and well-marked. Whether or not Murchison was right in claiming an Ordovician age for the thin-bedded gneiss is another question; but, in the writer's opinion, there is not a shadow of doubt that it is quite distinct from the Lewisian, and of less antiquity. The Pebidian rocks of Anglesey furnish us with another illustration of the necessity of comparing formations as a whole. In some parts of Northern Anglesey, the slaty rocks are highly altered, so as here and there to put on the form of a true metamorphic schist, which approaches in texture and composition some of the chloritic bands of the older gneissic series.

But a careful study of the whole district leads to the conclusion that these altered patches are subordinate parts of a comparatively unaltered group which, taken as a whole, differs widely from the more ancient series, which is thoroughly metamorphosed from top to bottom.

In studying the lithology of a formation, its *degree of metamorphism* is an important factor in the evidence. Sufficient material has not yet been collected to form the basis of a theory; but, so far at least as England and Wales are concerned, the researches of the last few years lend some support to the opinion that regional metamorphism is found only in Archæan rocks, and that the degree of alteration is proportioned to the antiquity of the group. Murchison held that the Malvern metamorphic rocks were altered Cambrian, but no one now doubts their Archæan age. The "altered Cambrian," mapped by the Geological Survey as forming a band flanking each side of the granitoid axis of St. Davids, clearly underlies the basement conglomerates of the Lower Cambrian, and is the typical Pebidian of Hicks. The "altered Caradoc" which is found here and there in the central Salopian chain is sometimes an unaltered rock, sometimes a quartzite whose Archæan age cannot be disproved, but generally it is a part of the great Archæan volcanic series. The altered rocks of Anglesey, the "metamorphic Cambrian and Silurian" of the Survey, are shown by a variety of evidence to be older than the Cambrian. Rocks of precisely the same mineral character, showing the same order of succession, and lying on the same strike, are sometimes coloured by the Survey as "Cambrian," sometimes as "Silurian." True Cambrian and "Silurian" strata do indeed occur in many parts of Anglesey, and they have given their name on the map to the metamorphic rocks which happened to be near them; but *in no case* are there any signs of a transition between the altered and unaltered beds. The evidence, then, on which the Cambrian and "Silurian" age of the metamorphic rocks of Anglesey has been based proves, on a critical examination, to be unsound, and indeed, in some cases, self-destructive. Along the north-western margin of Caernarvonshire are bands of supposed "altered Cambrian," which in like manner turn out to be of greater antiquity. The partially altered rocks of the Charnwood Forest area, regarded as Cambrian by the Survey, are now, as previously shown, considered to be Pebidian. Every case of supposed metamorphic Cambrian or "Silurian" has been invalidated by recent researches, and we are driven to the conclusion that within the English and Welsh area there is a presumption in favour of the supposition that any district of altered rock which may be discovered is of Archæan age.

That the degree of metamorphism is proportioned to the antiquity of a rock-group is strongly suggested in England and Wales. The Pebidian of St. Davids has undergone chemical change, but has not been converted into a crystalline schist. Shales have become chloritic, felspathic mud has been changed to hornstone, and volcanic ash has been indurated into a rock bearing a superficial resemblance to greenstone. The Pebidian of Anglesey is very similar, but in some patches the alteration has proceeded further. Near Bangor, in Shropshire, and in Charnwood Forest, incipient metamorphism has also taken place in a greater or less degree. All these rocks may fitly be classed with the "hypometamorphic," a term used to express a partial change.

The Dimetian series of St. Davids has undergone a much greater change. The prevailing types are quartzite and a rock like granite, but of metamorphic origin, being in fact a metamorphosed quartzo-felspathic grit. In Twt Hill, Caernarvonshire, and in Central Anglesey are similar granitoid bands. In the latter locality this rock passes down into schistose and gneissic strata (Fig. 1). The alteration in these schists is complete. The rocks are thoroughly crystalline and truly foliated. But comparing them with the Laurentian or Lewisian gneiss, a clear difference is perceptible. In the Anglesey group there are here and there indications of the original fragmental structure. In the granitoid band are intercalated some beds of felspathic breccia, and in the schists angular or rounded grains of quartz may sometimes be detected. The crystallization of these schists is also much more minute than in the Lewisian. The metamorphism of the latter is intense, no trace of fragmental origin being perceptible, while the constituent minerals occur in distinct and frequently in large crystals. The Pebidian, the Dimetian (to which the Anglesey gneissic series probably belongs), and the Lewisian thus present three degrees of metamorphism, the partial, the moderately complete, and the intense. Corresponding with these degrees, it is to be observed that the Pebidian is certainly newer than the Dimetian, and the Dimetian is probably newer than the Lewisian.

Between the Pebidian and Dimetian, Dr. Hicks has intercalated a new group, the Arvonian, which he considers to present an incipient gneissic structure, and to be intermediate in degree of alteration between the oldest and youngest series. Should these views be established, the hypothesis suggested in this section would receive additional confirmation.

In investigating the degree of alteration, it is important to bear in mind the influence of *selective metamorphism.* The forces which alter rocks may select one bed, and convert it into a schist, while strata below are comparatively unaltered. A rock which is mainly composed of quartz can undergo little change, because quartz is a simple mineral which cannot be decomposed by any of the chemical processes which are at work in the earth's crust. A quartzose sandstone is metamorphosed into quartzite, which differs chiefly in induration and texture. But a felspathic shale may be changed into something widely different. By the separation of a part of the silica, the felspar may be converted into mica, and the mica and silica (quartz) together would form mica-schist. If a portion of the felspar remained undecomposed, the quartz, felspar, and mica would constitute a gneiss or granitoid rock. Selective metamorphism may therefore complicate our researches by changing parts of a younger group into the likeness of an older deposit. As previously urged, we must compare formations, not piecemeal, but as a whole.

It is scarcely necessary to utter a caution against confounding *regional* with *contact* metamorphism. The change produced by an intrusive mass of granite or greenstone rapidly dies out as we recede from the point of contact, and is readily distinguished in the field from the metamorphism which uniformly affects large rock-groups. Contact alteration may be found in any formation into which igneous rocks have been intruded, and it therefore affords us no aid in Archæan work. There would also appear to be no *à priori* reason why regional metamorphism should not also occur in rocks of any age, and in the above remarks it is only contended that there are some grounds for constructing an empirical rule, applicable only, so far as present observations go, to a certain area. When the nature and causes of metamorphism are more thoroughly understood, it may be possible to reach a general principle.

Dr. Sterry Hunt, of Montreal, has very ingeniously attempted, in his "Chemical and Geological Essays," to prove that the Archæan rocks of North America display a progressive chemical and mineral change from the oldest to the youngest; so that the minerals of a group, like fossils in newer deposits, are indices of its geological age. The writer does not here express an opinion upon this hypothesis, as it is his design to confine himself to reasonings based upon facts of which he has had personal cognizance.

In correlating Archæan groups, it is important to ascertain the *origin* of the deposits. In the Pebidian at St. Davids there is abundant evidence of contemporaneous vulcanism; indeed, the series is mainly built up of volcanic ashes and breccias. The same origin is attributed to the Bangor group, to the younger of the two Anglesey series, to the newer of the two Archæan groups at Malvern and in Shropshire, and to the Charnwood Forest rocks. We must not, of course, press this argument too far, but it adds strong confirmation to other proofs. It is much weaker in the last case than in the others, because by superposition the Charnwood series can only be proved to be pre-Carboniferous. In all the examples, the Arvonian of Dr. Hicks introduces complexity. It is of volcanic origin, at least in great part; but it is not yet certain to what horizon it is to be referred—to the Dimetian, to the Pebidian, or to a period between the two. It is also doubtful if all the rock-groups which have been called Arvonian are of the same age. So far, at least, as Anglesey is concerned, the Arvonian has no independent existence, but is simply a band in the gneissic series. In this area, the (supposed) Dimetian also displays the characters of a volcanic rock, where the alteration has not gone far enough to obliterate the original structure; but this need not prove a practical difficulty, as the more intense metamorphism of this group as a whole will readily distinguish it from the Pebidian.

The microscope is a most valuable auxiliary in Archæan geology. It cannot supersede field-work, but it gives precision to the determinations of the pocket-lens, and it sometimes ascertains structure which would otherwise remain uncertain. The oft-repeated objection that "we cannot study mountains in the microscope" is met by the practical refutation that we have found out by its aid things which the hammer, the lens, and the acid-bottle had not discovered. The enforcement of this point belongs, however, to the professed microlithologist.

The *strike* of a series has frequently been used as an aid in correlation. It was long since pointed out by Murchison that the Lewisian of Scotland has a general strike to the north-west, while the newer gneiss series strikes to the north-east. It was rightly argued that such a divergence of strike indicated a great difference in age. The gneissic rocks of Shropshire and the Malvern Hills, resembling the Lewisian as they do in their lithological structure, possess the same strike, and the fact is held to confirm the correlation of the English groups with the northern type. The Pebidians of St. Davids strike about east and west, and this is the prevailing lie of the contemporaneous series in Anglesey. The volcanic rocks of Shropshire also strike in the same direction. On the other hand, the volcanic series of Charnwood Forest, presumed to be of the same age, has the strike of the Lewisian. Other facts also tend to show that this test is of uncertain value. The utmost we can safely assert is that if there are other good reasons for believing two groups to be contemporaneous, a coincidence of strike will, within certain limits, add to the weight of evidence. Strikes are not so uniform as has sometimes been represented. Over large portions of the Northern Highlands the strike of the Lewisian is *not* to the north-west, and that of the newer gneiss series is *not* north-east. Also in Anglesey and Shropshire the volcanic series frequently deviates widely from the normal strike. These frequent divergences are probably due to faulting and to the influence of intrusive masses. In large areas, in which the original axes of upheaval have not been so broken and distorted as to confuse their prevalent direction, the strike test will be of much greater service than in a small isolated district, in which there is not room for the principal lines of movement to assert their supremacy over subsequent disturbances.

In Archæan work the evidence is generally cumulative. Any one test taken alone may not produce conviction. Mineral characters, included fragments, strike, origin of deposits, state of alteration, even similarity of succession, may not always remove a suspicion that the resemblance is due to coincidence, or to a general cause which may occur in more than one group. But we are rarely left to one line of proof, and every additional test strengthens the evidence in an increasing ratio. Only field-work can supply the full testimony. Each tap of the hammer may help to build up the conclusion. The results grow as section after section is observed, and hundreds of minute facts, which cannot be published, or even recorded without incalculable labour, gradually bring home conviction to the mind.

In concluding these observations, the writer would strongly insist upon the necessity of *thorough* and *detailed* work. Where the ground is so broken and contorted, almost every rood, in critical sections and areas, must be hammered over. Grave error may lurk in any overlooked fault or reversal. It sometimes takes weeks of hard toil to arrive at a result which may be expressed in a line. Facts, seemingly conflicting, keep the mind in discouraging perplexity, till one more blow of the hammer strikes out a spark which illuminates the seeming chaos, and reveals the harmony of the whole. Patient work will hardly fail to unearth new truths even in the most battered and metamorphosed patches of the crust. The results to be obtained are surely neither uninteresting nor unimportant. As the astronomer, by inventing new instruments, penetrates more deeply into the remote abysses of stellar space, and resolves dim nebulæ into groups of suns; so the Archæan geologist strives to reach further and further back towards the beginnings of the earth, and refuses to accept a barrier to his further investigations.

VII.—Possible Laurentian Rocks in Ireland.

By G. H. Kinahan, M.R.I.A., etc.

As the Archæan geologists have turned their attention to the Old Irish rocks, perhaps it may be allowable to give a short description of them.

This school of geologists from their published papers would seem to lay great stress on lithological characters; while to me it would appear that Petrology, or the stratigraphical position of rocks or rock masses, was more important. Some of the changes found in rocks, that geologists suppose to be petrologically the same, they state are quite impossible by chemical laws; but as such changes are quite palpable to field geologists, I would suggest that possibly the Chemist is acquainted with some laws to them unknown.

The Irish rocks that have been suggested to be of Pre-Cambrian age are metamorphic and granitic rocks in the Carnsore district, S. E. Wexford; metamorphic and granitic rocks in West Galway and S. W. Mayo; gneissose rocks in Erris, N. W. Mayo; metamorphic and granitic rocks in Donegal and parts of Derry and Tyrone; while rocks that will possibly be so classed are metamorphic rocks in N. E. Antrim near Ballycastle.

The rocks of the Carnsore or S.E. Wexford district I have very carefully worked out, and to me it appears that northward and westward they gradually merge into unmetamorphic rocks; and in the latter are found *Oldhamia*, a Cambrian fossil.

The West Galway and S.W. Mayo rocks have also been carefully worked out. In them there are two zones of hornblendic and pyroxenic rocks; lithologically very similar, if not identical, with the Laurentians of America and Scotland; but at the same time perhaps more like the Huronian rocks; especially those of the lower zone, as Logan's description of the Huronian rocks would do for the latter. The rocks of the upper zone lie above others that contain fossils which have been pronounced by Harkness, Baily, and other authorities to be of Llandeilo types. In portions of the area the newer rocks are more metamorphosed than the older, and to me it would appear that it is the newer rocks that are now suggested to be Pre-Cambrian. The older rocks in previous publications I have suggested to be Upper Cambrians (Arenig rocks). The rocks supposed to be Upper Cambrians seem to extend north-east across Sligo, into Leitrim, near Manor Hamilton; possibly they also occur between Charlestown and Ballaghaderreen in N.E. Mayo. The latter small exposure was considered by Griffith and Jukes to be of old rocks, although now they have been joined on to the associated fossiliferous Silurians (Lower Old Red Sandstone). Such a classification, however, must be petrologically incorrect; as these older rocks were upturned, contorted, and considerably metamorphosed and denuded, prior to the Silurians being deposited on them. This is proved by the younger rocks being made up of the detritus of the older ones. These metamorphic rocks, as I have pointed out in a paper published by the Royal Irish Academy, although lithologically very similar to the lower zone (Arenig rocks) of West Galway, are also like those of the upper zone, and possibly may be of the latter age (Llandeilo).

The gneissose rocks of Erris, N.W. Mayo, are a remarkable group, Griffith and the different other early geologists pointed out that they seemed to be much older than the associated metamorphic rocks. Microscopically they seem to be identical with the rocks of Carnsore, and for this and other reasons, mentioned in a paper read before the Royal Geological Society of Ireland, I suggested that they were of Cambrian age. All that can be positively asserted about them is, they are older than the associated metamorphic rocks. But what is the age of the latter? They are said to be of Cambro-Silurian age; yet in composition, aspect, etc., they are very similar to the rocks south of Louisburgh, in the same county, that have been proved by Symes to be Silurians. Their position only, therefore, does not prove them to be older than Cambro-Silurian.

In Donegal and the adjoining parts of Derry and Tyrone there is a large tract which was formerly supposed to be occupied solely by metamorphic and granitic rocks. But of late years Dr. King, of Galway, has discovered in Kilmaghrenan impressions that seem to be of fossils of Cambro-Silurian age; this however is not as yet positively proved, as some authorities deny that they are fossils. In the S.E. of this area (Co. Tyrone), as I have proved in a paper published by the Royal Irish Academy, there are very old rocks to the north of Pomeroy, while to the N.W. there are also very old rocks, which years ago were suggested by Jukes to be of Laurentian age, on account of their likeness to the Scotch Laurentians. Now, however, if King is correct, it is possible they may be only Cambrians, overlaid by Cambro-Silurian; the latter in part highly metamorphic, as is the case elsewhere.

It must, however, be allowed that nowhere in Ireland are there rocks lithologically similar to those of Donegal; the nearest approach to them being some of the metamorphic rocks of N.W. Galway; but the latter stratigraphically are Cambro-Silurians

(L. Landeilo). Lithologically they are quite distinct from the type specimens in the different collections of the American and Scotch Laurentians; while many if not all of them will be found in the collections of the type specimens of the Huronian rocks. It is therefore evident it is not by lithological character that the age of the older rocks of Donegal can be determined, but by careful field work and examination of all the rocks between them and the fossiliferous Cambro-Silurian near Pomeroy in Tyrone; or, if King is correct, of those between them and his fossiliferous rocks in Kilmaghrenan. But this work must be more careful than that near Pomeroy, where the fossiliferous Cambro-Silurian rocks are classified with those on which they are deposited, although the latter were highly metamorphosed, upturned, contorted, faulted and denuded prior to the age of the younger.

Nothing as yet has been said by the Archæan geologists as to the age of the older rocks near Ballycastle, Co. Antrim. As however they appear to be of the same age as those in the hills northward of Pomeroy, Co. Tyrone, one age will have to be given to both; it is therefore necessary to mention them in a paper on this subject.

REVIEWS.

I.—Géologie de la Belgique. By Michel Mourlon, D.Sc., etc 2 vols., pp. 317 and 392, 2 Plates and 55 Woodcuts. (Brussels Paris, and Berlin, 1880, 1881.)

DR. MOURLON is well known as one of the most zealous among the younger geologists of the Continent. Since 1870 he has published numerous papers, many of which—those on the Devonian Rocks of Belgium, for instance—are of a high order of excellence. He has been for some time actively employed on the Geological Survey of Belgium, and the task of editing André Dumont's manuscript notes—of which three large volumes have already been issued —has been entrusted to him by his Government. Dr. Mourlon moreover occupies the post of Curator in the Natural History Museum at Brussels, and in the work under notice we have further evidence of unremitting labour added to much acumen and research.

It is impossible to avoid comparing this new "Geology of Belgium" with its able fore-runner, the *Prodrome d'une description géologique de la Belgique*, by Prof. G. Dewalque. The latter was published in 1868, and at that date was thoroughly satisfactory. But the progress of Geology during the last twelve years has been great—in Belgium as elsewhere—and a second edition of the *Prodrome* had become a necessity. Last year (1880) Prof. Dewalque surprised and disappointed the scientific world by publishing, not a new and improved edition of his valuable work, but a mere reprint of it, without addition, omission, or change of any kind. Under these circumstances we are bound to welcome Dr. Mourlon's book as supplying a greatly felt want, and we do so all the more readily that it is laid down to a great extent an the same lines as Dewalque's Prodrome, which is another way of saying that it is admirably planned.

The first volume is stratigraphical, and consists of clear and well-proportioned descriptions of all the rocks of the country, in ascending order. In most cases the views of other authors are very fairly stated and discussed, whether they be or not those held by Dr. Mourlon himself, and justice is done to even the very latest discoveries. We shall endeavour to point out the chief subjects referred to which are the outcome of work published since 1868, and which, therefore, may be looked upon as the justification of the book.

In the first place we find the important researches of Messrs. Renard and de la Vallée Poussin on the micro-petrography of the Ardennes igneous and metamorphic rocks duly recorded and illustrated by two capital tinted plates of microscopic sections, some of which are given here for the first time. The divisions of the Cambrian (*Salmian*, *Revinian*, and *Devillian*) are next considered, and the modern views of Dewalque, Gosselet, and Malaise compared with those of Dumont—nor is the correlation of these rocks with the Tremadoc Slates, Lingula Flags, Llanberis Slates, and Harlech Grits of Wales determined by the first-named writer overlooked. Among the Silurian rocks new matter of importance is included which is principally due to M. Gosselet and to the author himself. It is, however, in the account of the Devonian deposits that the value of the work done by both these geologists becomes most apparent, indeed the former may be said to have thoroughly mastered the many difficulties which beset the study of the Lower and Middle divisions (*Gedinnian*, *Coblentzian*, *Ahrian*, *Eifelian*), whilst the uppermost Devonian (the *Psammites de Condroz*), which many in Britain would prefer to regard as Lowest Carboniferous, has been equally completely dealt with by M. Mourlon.

On reaching the Carboniferous Rocks proper, justice is done to the recent investigations of Hull and Hardman, and Renard as to the origin of the chert so common in the Limestone Series, and to those of Dupont as to the division of that series, as developed in Belgium, into six members, each clearly defined palæontologically and, it would seem, also stratigraphically. Some of these members of the series appear to be often wanting, and it must be confessed that to any one accustomed to the Lower Carboniferous rocks of Britain, M. Dupont's maps of the Dinant district, in which these beds are shown as in a very network of faults, none of which is marked as doubtful, are apt to look as if they had been drawn up on somewhat too theoretical grounds. We cannot help thinking that Prof. de Koninck's old division into three may still be the more useful. The Coal-measures, considering their commercial importance, and the great interest attaching to the peculiarities of their lie in Belgium, are somewhat cursorily dismissed. Nevertheless their chief features are described, the flora discussed with reference to the work of Coëmans and Crépin, and the faults, natural pits, etc., with reference to that of Cornet and Briart, and others.

The Jurassic beds of Luxemburg do not appear to have been the subject of any striking observations since 1868, but the Cretaceous rocks have yielded numerous results of importance. Thus in the Wealden (*Aachenian*) of the Bernissart Colliery we have the recent discovery of several entire skeletons of Iguanodons of from nine to ten metres in length, together with numerous remains of land and river Chelonians. Here also are many freshwater fishes, the specific determination of which is not yet completed, as well as a Wealden Flora, consisting chiefly, according to Count de Saporta, of marsh plants, thus contrasting with those of the same age found at La Louvière, which, as the late Abbé Coëmans pointed out, are more or less Alpine in character. All these fossils occur in clay filling up a fissure in the Coal-measures. In the *Meûle de Bracquegnie*, a formation generally poor in fossils, Messrs. Cornet and Briart have succeeded in collecting some 120 specimens of Gasteropods and Lamellibranchs, Cephalopods and Brachiopods being remarkable by their absence. To the same associated geologists, and to Dr. Barrois, much of our improved knowledge of the subdivisions of the Belgian Chalk is also due. As to the Tertiary rocks which cover so much ground in Belgium, the mass of detailed observations of recent date which Dr. Mourlon has had to incorporate is perfectly enormous. This was to be expected in the classical birthplace of Tertiary Geology, and it is natural that the author should have felt it his duty to devote what, to non-Belgian readers, might appear almost too much space to these beds. Among the novelties in this department must be reckoned the application of Vanden Broeck's theory of the alteration of portions of deposits by the percolation of rain-water to the clearing up of many interesting points in the history of the many subdivisions recognized in these deposits. In connexion with this subject, as in many other cases, the author has had access to much unpublished material placed at his disposal by the investigators themselves, thus adding greatly to the value of his book as an original work.

The first 240 pages of vol. ii. consist of full lists of fossils from each formation, the rest being a complete bibliographical list of papers, books and maps relating to Belgian Geology. For the purposes of the palæontologist and the foreign "researcher" the usefulness of this part of the work cannot be overestimated.

As a second edition is sure to be called for, it may not be amiss to draw Dr. Mourlon's attention to some omissions which a hasty perusal of the "Bibliography" has revealed. English authors have suffered most, and we look in vain for the names of Dawkins, J. Geikie, Jenkins, Lebour, Simpson, and several others, some of whose writings bear on the geology of Belgium. The author has certainly not searched through the publications either of the Palæontographical Society of England or of the North of England Institute of Mining Engineers. Even the GEOLOGICAL MAGAZINE and the GEOLOGIST are all but ignored, and the Royal Society's Catalogue of Scientific Papers has not been put under contribution.

But fault-finding must end here, and we trust that what we have said before will make it evident to all interested in the rocks or fossils of the neighbouring continental shores that Dr. Mourlon has produced a work of sterling value, and one which, in the absence of Prof. Dewalque's long-expected second edition of his Prodome, must become the *vade-mecum* to all scientific travellers in Belgium.

G.A.L.

II.—TEXT-BOOK OF SYSTEMATIC MINERALOGY. By HILARY BAUERMAN, F.G.S. (London, Longmans, Green and Co., 1881.)

THE above work on Mineralogy by Mr. Bauerman, which was to have formed only one volume of the "Text-Books of Science," has been divided into two parts, in consequence of the systematic portion forming the present volume having been extended somewhat more than was originally intended, so that the physiography or descriptive mineralogy will be issued as a companion volume.

The geometrical properties and symmetry of crystalline forms, although treated in a general and sometimes original manner, occupy about one-half of the work, each of the six systems, their combinations and hemihedral forms being fully described, the derivation of the latter as well as the tetartohedral modifications are illustrated by shaded figures. The notations of Miller, Naumann, Weiss, Schrauf, and Levy are described; the faces of the crystals are marked according to Miller, except in the hexagonal system, where the Bravais-Miller method is used, but in the descriptive text the symbols of Weiss are sometimes noted, but those of Naumann are mostly given throughout.

Comparative tables of the different notations as well as the names proposed for the six systems by their authors would have been useful. The physical characters of minerals are concisely given and their optical and thermal properties are described at great length, considerable attention being directed to the subject of polarisation, and a table is appended showing the optical constants of the principal transparent minerals. The remaining portion of the work is devoted to the chemical properties of minerals, the relation of form to chemical composition, and the association and distribution of minerals. The latter may be usefully consulted as bearing on this interesting part of mineralogical science, as it treats in a clear and concise manner of the origin, alteration, pseudomorphism, and paragenesis of mineral substances.

A few minor points may require revision, but the work will be found a useful guide to students desirous of acquiring a general knowledge of the subject, as well as serve as an elementary introduction to larger text-books,—the main objects the author had in view in preparing the present volume.

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ORIGINAL ARTICLES.

I.—On the Discovery of Coal-measures under New Red Sandstone, and on the so-called Permian Rocks of St. Helens, Lancashire.

By A. Strahan, M.A., F.G.S.;
of H.M. Geological Survey.

DURING the last few years the Coal-measures have been reached through the overlying New Red Sandstone in three collieries, and in three bore-holes, in that part of South Lancashire which lies between the St. Helens and Wigan Coal-fields and the River Mersey. The results were in some degree unforeseen, as the Trias was thinner than might have been expected, while it seems likely that the Permian formation is altogether absent.

In the eastern part of this district, the Permian rocks, proved in the shaft at Edge Green, and identified by Mr. Binney,[1] overlie the Coal-measures, and, the Lower Mottled Sandstone being absent, are succeeded by the Pebble Beds of the Bunter. To the westward they are overlapped by the Pebble Beds, which then rest on the Coal-measures; but proceeding in the same direction, the Lower Mottled Sandstone comes in, appearing first at Ashton, and extending thence all along the southern boundary of the Coal-field. The Permian rocks, after having been overlapped for a distance of about five miles, were believed to reappear from beneath the Trias at St. Helens Junction, the evidence of this consisting in the identification by Mr. Binney of a bed of shale, 30 feet thick, and an underlying soft sandstone about 90 feet thick, as Permian Marl and Lower Permian Sandstone respectively. The marl was met with in a well, but the sandstone is exposed in a quarry. It is "altogether undistinguishable" from the Lower Mottled Sandstone, as stated by Prof. Hull.

On the strength of this appearance of supposed Permian rocks from under the Trias, it was believed that this formation was present under a large part of the Triassic area, and with a boundary approximately coinciding with that of the Trias, but that, owing to the unconformity of the two formations, the Permian was overlapped at intervals, so as not to appear at the surface at all.

From this interpretation of the country, it would have been expected that on sinking through the Trias towards the south, a more perfect development of the Permian would be found than

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[1] Mem. Lit. and Phil. Soc. Trans. of Manchester, vol. xii.

exists at the outcrop towards the north, where the overlap is nearly complete, owing to the supposed partial or entire removal of the Permian strata by denudation before the Trias was deposited. That these expectations would not have been fulfilled is shown by the result of the sinkings about to be described. It may be added that any complete examination of the rocks at the surface is prevented by the prevalence of drift.

In the years 1875–1878 two shafts were sunk by the Bold Hall Colliery Company on the southern margin of the Bold Peat Moss, about one mile from the outcrop of the supposed Permian Rocks at St. Helens Junction.

The following is an abstract of a section of the strata supplied to my colleague, Mr. C. E. De Rance, F.G.S., by Mr. Harbottle, and published in full in the Geological Survey Memoir on the Neighbourhood of Prescot (3rd edition):—

		feet.	ins.
Post-Glacial and Glacial		67	11
Lower Mottled Sandstone	Red marl and sandy marl	9	0
	Red mottled sandstone	21	0
So-called Permian	Red and white metal (shale)	30	4
	Red sandstone	57	9
Coal-measures	Red Coal-measures	364	9
	Coal-measures	1249	6
	Florida Mine		

It will be noticed that the shale, which was supposed to be of Permian age, is about the same thickness here as at the outcrop, but the underlying sandstone is 32 feet 3 inches thinner.

At Collins Green about three-quarters of a mile to the north-east of this colliery, but about the same distance from the boundary of the Trias, two shafts have been sunk by the Collins Green Colliery Company. The following is an abstract of a section, for which I am indebted to the kindness of Mr. John Mercer, and which is given in full in the memoir mentioned above:—

		feet.	ins.
Glacial Deposits		63	7
Pebble Beds and Lower Mottled Sandstone; red and yellow sandstone		181	0
So-called Permian	Red shale	22	4
	Hard dun sandstone	3	3
	Loose brown sandstone with "Sulphur-balls"	40	8
Coal-measures	Red Coal-measures	151	11
	Coal-measures	1204	10
	Florida Mine		

The supposed Lower Permian Sandstone shows here a further diminution in thickness of 13 feet 10 inches, and the red shale is 8 feet 2 inches thinner than at the outcrop. The "Sulphur-balls" referred to in the section are spherical or slightly flattened concretions of iron pyrites. They were found in great abundance in a loose brown sand, composed of small perfectly rounded grains of quartz. On breaking open a concretion, these grains of sand are seen to make up the greater portion of the material. They are arranged in their original bedding planes, and held by a cement of iron pyrites. I was informed that the unconformity between this bed and the underlying Coal-measures was clearly visible in the shafts; the dip of the former was at 6° to the south-east, that of the Coal-measures at 10° in the same direction.

At a distance of 1 mile to the north-east, and still about the same distance from the boundary of the Trias, three shafts are being sunk by the Haydock Colliery Company, giving the following section:—

		feet.	ins.
Glacial Deposits		40	0
Pebble Beds.	Red sandstone	259	0
So-called Permian	Red shale or "soapstone"	9	0
	Hard brown sandstone	7	6
Coal-measures.	Red Coal-measures	97	9
		413	3

By the kindness of Mr. Glover, the manager of the Haydock Collieries, and of Mr. Burns, who was in charge of these sinkings, I was able to examine the lower beds of the Red Sandstone and their junction with the Coal-measures. The Pebble Beds in which the sinking commenced, and which are exposed on the surface close by, seemed to extend to a depth of 299 feet from surface. Though pebbles were scarce, the stone contained rolled lumps of clay, and resembled this subdivision in its hardness and general appearance. The "soapstone" is a bed of red shale, of an ordinary Triassic type, such as is met with in the Pebble Beds or in the Lower Mottled Sandstone. The hard brown sandstone underneath it resembles the Pebble Beds in containing fragments of shale and small grit, but also shows the "millet-seed" grain, consisting of small round grains of quartz, scattered through a finer compact matrix, which is so often seen in the Lower Mottled Sandstone.

The top of the Coal-measures, a bed of shale, showed signs of having been broken up, and redeposited, for a depth of about 3 or 4 feet. The dip of the "soapstone" and hard brown sandstone is towards the east at 7° or 8°, that of the Coal-measures in the same direction at 13° or 14°.

It seems probable that the "soapstone" of this Colliery is the same bed of shale that was met with in the Bold Hall and Collins Green Collieries, and which crops out at St. Helens Junction under the name of Permian Marl. A comparison of the sections at these four localities shows that this bed with the underlying sandstone thin out with great regularity in proceeding from west to east. It should be noticed that the attenuation takes place in the sandstone as well as in the marl. If they had been *unconformably* overlapped by the Trias, the marl would have been overlapped first, the sandstone retaining its thickness, except in those places where, by the removal of the marl in pre-Triassic times, it had been exposed to a similar denudation.

Three miles to the south of St. Helens Junction, and rather farther from the Triassic boundary than these collieries, the Trias was penetrated in a bore-hole, made in search of water near Farnworth. The section, of which the following is an abstract, was supplied to me by Mr. Timmins, of Runcorn:—

		feet.	ins.
Lower Mottled Limestone	Fine-grained yellow and white sandstone	124	0
	Light-green, red, and blue clay	3	0
	Bright red sandstone........................	3	0
Coal-measures.	Purple and mottled marl, with bands of limestone ..	40	0+
		170	0

The supposed Permian rocks are therefore either altogether absent here or are represented by 3 feet of clay, and 3 feet of sandstone only, and this in a direction in which, according to the former interpretation of the country, they might have been expected to be present in force.

The boundaries of these so-called Permian rocks have thus been traced under the Trias from their outcrop in every direction. They rest unconformably on the Coal-measures, but there is certainly no unconformity between them and the Trias, the overlap being due to the natural thinning out of the beds, and not to their having suffered denudation before the Trias was deposited. Taking also into consideration that the sandstone, as stated by Prof. Hull, is "altogether undistinguishable" from the Lower Mottled Sandstone, and that the shale is of a type very commonly met with in the Trias, I think that the identification of these rocks as Permian is rendered exceedingly doubtful.

Nor in my opinion is it probable that any Permian rocks are present under the Trias of South Lancashire, west of Warrington. The beds in the Edge Green Colliery Shaft, which were identified by Mr. Binney as Permian, appear to be absent under the Trias at Parkside and Winwick, two miles and a half and four miles and a half to the south respectively. A bore-hole at Parkside, from which I was shown specimens by Mr. Timmins, passed through the following beds:—

		feet.
Pebble Beds.	Red, brown, and white sandstone, with pebbles	150
Lower Mottled Sandstone.	Red shale	32
	Bright red and yellow sandstone with shale 4 feet, and containing concretions of iron pyrites towards the base	109
Coal-measures.	Purple and green mottled marls	5 +
		296

And at Winwick specimens of the following beds were obtained by Mr. Timmins:—

		feet.	ins.
Pebble Beds.	Hard sandstone, with pebbles and thin beds of shale..	229	5
Lower Mottled Sandstone.	Red shale	31	7
	Soft sandstone	16	5
	Soft grey sandstone, with concretions of iron pyrites	21	7
	Dull-red sandstone, with bands of shale............	31	0
	Shale	11	0
Coal-measures.	Dark-red, green, and purple marls, with limestone ..	71	0
		412	0

These two sections commence without doubt in the Pebble Beds, which are well exposed on the surface in both localities. It is difficult to select a base-line for this sub-division, though the bright-coloured soft sands certainly belong to the Lower Mottled Sandstone. It is interesting to find here concretions of iron pyrites in a similar position to those found at Collins Green. They differ in shape, being twig-shaped instead of spherical, but resemble them in consisting of sand cemented by iron pyrites. These concretions probably owe their origin to the action of water carrying sulphides in solution, rising from the Coal-measures, and meeting with the peroxide of iron which forms the colouring matter of the Trias. In both cases the rock containing them had lost its colour.[1]

The dark purple and green marls associated with limestone at Winwick and Farnworth, and the similar beds, but without limestone, found at Parkside, accord with those which have been long known in a railway cutting near Whiston. They are probably the equivalents of the limestone series in the Upper Coal-measures of Manchester, where they are associated with valuable seams of coal and ironstone, and are known as the Ardwick Limestones.

The limestone found in the Winwick bore-hole was of a dull red colour and earthy texture, and showed a brecciated structure in parts, consisting of small fragments of grey limestone imbedded in a red earthy matrix. At Farnworth, beds of grey limestone also were found. Both the marls, the red earthy and the grey limestones, brecciated in parts, and the purple and green marls, may be found in the railway cutting at Whiston, so similar in character that specimens from this section and from the bore-holes cannot be distinguished. In order to complete the comparison, I submitted specimens of the Winwick Limestone, with fragments from Ardwick and Whiston, to Mr. Siddall of Chester, for examination under the microscope. They were all found by him to contain *Microconchus carbonarius,* thus rendering the identification almost certain. The purple colour of the marls at these localities is due to the infiltration of colouring matter from the overlying Trias. It will be seen that at Bold Hall this staining extended to a depth of 364 feet 9 inches, and at Collins Green to 151 feet 11 inches in the Coal-measures.

Up to the present time, nothing further is known of these Upper Coal-measures in this district, as the borings, which were in search of water, were stopped on entering them. There is no doubt that they overlie the whole of the productive Middle Coal-measures of Lancashire. The dip of these Coal-measures along the southern margin of the Coal-field being generally to the south-east, and at a steeper angle than the Trias, they are succeeded in this direction by higher beds, which cropping out in the old denuded floor of Coal-measures on which the Trias rests, never rise to the surface at all. The limestone series at Ardwick is underlain at a distance of 600 feet by the Bradford and Clayton Coal Series, but of the beds intervening between this Coal Series and the Middle Coal-measures nothing is known, except that strata, of a thickness of 1678 feet, exposed in the valley of the Irk, belong to this part of the series. (Geol. Survey Memoir on Country around Oldham). There is reason to believe that this great mass of unproductive measures

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[1] The iron having segregated out.

separating the Upper and Middle Coal-field may be reduced in thickness towards Wigan, and still further in the district under consideration, as it is known that the Middle Coal-measures lose about one-third of their thickness between Wigan and Prescot (Vertical Sections of the Geol. Survey, Sheet 61).

It is possible, then, that future exploration may prove the existence at no great depth of equivalents of the Bradford and Clayton Coal-seams in the measures which underlie the Trias, north of the positions of the bore-holes where the limestone was proved, but south of and overlying the 1100 feet of unproductive strata met with in the Bold Hall and Collins Green Collieries. Whether the seams, if they exist, are likely to prove sufficiently valuable to repay the cost of sinking to them must remain for the present a matter of speculation. The observation that the attenuation of the measures referred to above as taking place between Wigan and Prescot is accompanied by a deterioration in the quality of the coal in the same direction is not in favour of their doing so. In the absence of good coal in these beds, the great mass of unproductive measures that would have to be penetrated to reach the productive Middle Coal-measures, when added to the thickness of overlying Trias, will prevent the Triassic areas bordering the Mersey from becoming a repaying coal-field, at least until the more accessible fields have been more nearly exhausted than at present.

II.—NOTE ON THE PITCHSTONES OF ARRAN.

By S. ALLPORT, F.G.S.

IN 1872 I published in the GEOLOGICAL MAGAZINE (Vol. IX. p. 1), a brief account of the Arran Pitchstones, in which I figured and described the singularly beautiful groups of minute green crystals which are so characteristic of the rocks on the eastern shore of the island. I have since cut many additional thin slices, and have long been aware that my paper contains an error, which I will take the present opportunity to rectify. The groups of crystallites to which I refer are described on page 2 and illustrated, Plate I. Fig. 1, and contain the "long slender prisms of a green pyroxenic mineral" there mentioned. In the last paragraph, p. 9, these green prisms are again mentioned, and are said to be augite, instead of hornblende, as stated by Zirkel in his description of the same rock. The grounds for this conclusion were twofold, the absence of dichroism, and the presence of undoubted crystals of augite. After pointing out that the pale green crystals exhibit no trace of dichroism, I added, "Unless, therefore, it can be shown that some hornblende is not in the least dichroic, the mineral in question must, on this ground alone, be regarded as augite."[1] As regards the latter mineral, there can be no doubt whatever of its occurrence, for in addition to the crystal described in the paragraph just quoted, I may now add, that it is far from uncommon, perfectly characteristic examples having been observed by me in specimens from several different localities in the island. Having obtained on the former occasion clear proof of the presence of augite, I have now to admit, that there is equally strong

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[1] *Op. cit.* p. 9.

evidence that the long green crystals are hornblende. In a specimen from the Pitchstone vein on the Corriegills shore, many of the green, prisms are larger than usual, and happen to lie in positions either nearly or quite vertical to the plane of the slice, so that the angle of ∞P may be readily measured; in all favourable positions it is found to be a very close approximation to 124° 30′. The larger prisms which lie in the plane of the slice resemble crystals of actinolite, and, like them, are often traversed at irregular distances by transverse fractures. The angle of extinction is always small, but varies from 3° or 4° to about 15°. There can be no doubt therefore that the mineral is hornblende.

The mineral constitution of the Arran Pitchstone may now be regarded as definitely ascertained. The rock consists of a structureless glass, in which are imbedded the following minerals—two felspars, orthoclase and a triclinic species, bipyramidal quartz, hornblende, augite and magnetite, all of which occur occasionally in more or less perfect crystalline forms. The glassy matrix is clear and colourless, but the innumerable crystallites of hornblende with which it is crowded impart to hand-specimens their well-known shade of dark glossy green.

MASON COLLEGE, BIRMINGHAM.

III.—THE BASEMENT BEDS OF THE CAMBRIAN IN ANGLESEA AND CARNARVONSHIRE.

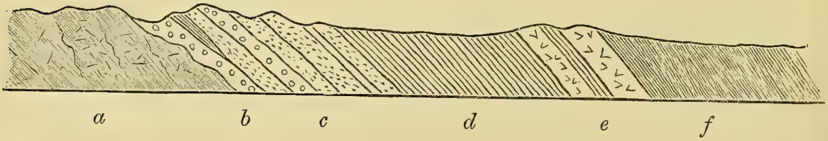
By R. D. ROBERTS, M.A., D.Sc. (Lond.), F.G.S.,
Clare College, Cambridge.

THE following facts were observed during a visit to Anglesea and Carnarvonshire in company with Prof. Hughes in the early part of July. They still further bear out and confirm the evidence given in a short communication to the GEOLOGICAL MAGAZINE for May, 1881, bearing upon the position of the Twt Hill conglomerate. Among the arguments brought forward against the Cambrian age of that conglomerate, much stress has been laid upon the absence from it of felsite pebbles, which are so characteristic of the Cambrian conglomerate in the neighbourhood of Bangor.

In the former paper I stated that fossiliferous Cambrian shales and sandstones had been traced down by Prof. Hughes at two or three points in Anglesea into a quartz conglomerate, lithologically not distinguishable from the Twt Hill conglomerate. We have now traced this conglomerate, which always passes up into brown sandstones that are sometimes fossiliferous, over a considerable area round Llanerchymedd, and found it always resting upon and following the contours of the pre-Cambrian axis. It presents variations both in thickness and in lithological character. In a quarry near the windmill half a mile east of Llanerchymedd, bands of conglomerate, largely made up of felspathic fragments, alternate with bands of pure quartz conglomerate of the Twt Hill type. Half-way between this quarry and Llanerchymedd, in a bye-road on the south side, the conglomerate is seen to be actually divided by a band of shale from ten to twenty feet thick; the conglomerate above and below the shales being made up of quartz pebbles. At Penygraig, near Penlon, about four miles south of Amlwch, a still more interesting example of variation in the character of the conglomerate is shown. The basement bed resting on the granitoid axis at Penlon presents all the characteristic features of the Twt Hill conglomerate. Higher up at Penygraig a band occurs composed almost entirely of felsite pebbles; different parts therefore of the same conglomeratic series present lithological characters as diverse as the characters of the felsite conglomerate of Bangor and the quartz conglomerate of Twt Hill. Towards the S.W. of Anglesea the conglomerate ceases to be a quartz conglomerate and West of Llanfaelog is made up largely of fragments of green felspathic rocks.

In thickness the variations are also considerable. At Prys Owen Fach, 1½ miles S.W. of Llanerchymedd, the conglomerate is represented by a thin band, only a few inches thick at the base, of the fossiliferous brown sandstones, and resting upon the gneiss; while farther to the S.W., near Llanfaelog, the thickness appears to be very great. The Cambrian succession in Angelsea may be represented diagrammatically as follows:

Generalized Section across Lowest Beds of Cambrian.



a. Pre-Cambrian axis.
b. Conglomerate of variable thickness, sometimes a pure quartz conglomerate, sometimes made up of felsitic material, and sometimes showing alternations of bands of sandstone or slate.
c. Brown sandstones, sometimes containing *Orthides*.
d. Black or grey shales, sometimes banded.
e. Black brecciated ashy-looking shales with fossils.
f. Black shales, containing *Graptolites*.

Turning to Carnarvon the succession is seen to be precisely similar.

At Pontseiont black shales containing Graptolites occur dipping S.S.E. Walking across the strike towards the Pre-Cambrian axis of Twt Hill, brown sandstones are met with at the entrance of the Twt Hill quarry, dipping S.S.E., which pass down at once perfectly conformably into the well-known conglomerate of quartz pebbles which rest against the granitoidite.

The sequence is in every particular similar to that in Anglesea, both in respect to the lithological character of the several beds, and in their relation to the pre-Cambrian axis. No one who has studied the beds in Anglesea can feel a doubt as to the position of the Twt Hill bed.

The resemblance between the two areas may be still farther followed up.

The Twt Hill conglomerate traced from Carnarvon towards Bangor appears to thin out, and is not seen beyond the quarry between

Tygwyn and Ysyuborwen, about half a mile N.E. of Carnarvon. The brown grit and sandstones, however, are well exposed about three miles to the N.E. at Carreg Goch, dipping at a high angle to the S.S.E., and apparently dipping under black shales. Still farther north-east, but south of Llanddeiniolen, similar beds are seen containing hard bands of quartz pebbles, dipping as before S.S.E., and succeeded by black shaly beds. North of Llandeinidlen the conglomerate becomes felsitic. The actual base of the series is not seen, the lowest bed exposed being a grit of quartz and felsite passing up into a conglomerate composed of felsite pebbles.

This seems to furnish a parallel instance to that at Penygraig and Penlon, in Anglesea, referred to above, where two conglomerates occur, a quartz conglomerate below, and a felsite conglomerate above separated by quartz sandstones.

There is, therefore, nothing exceptional in the fact that a conglomerate exhibits very different lithological characters in different parts of even a limited area. If anything more is needed to show that the lithological difference between the conglomerates of Twt Hill and Bangor is no valid argument against the Cambrian age of the former, I need only state that on the shore of the Menai Straits, near Garth Ferry, Bangor, a band of quartz conglomerate occurs high up in the Cambrian, which lithologically so closely resembles the Twt Hill conglomerate, that if a number of unlabelled specimens from the two places were mixed together, it would be extremely difficult, if not impossible, to re-sort them. The sandstones in which the conglomeratic band occurs may be traced down some 400 or 500 feet into the felsitic conglomerate which forms the base of the series in that area.

It appears therefore that whatever objections there may be to regarding the Twt Hill conglomerate as the base of the Cambrian in the Carnarvon area, the stratigraphical evidence, as Prof. Hughes has already shown by careful mapping, is all in favour of that view. The identity of sequence in Anglesea and at Carnarvon constitutes an argument of the greatest weight, which no lithological difference such as the conglomerates of Bangor and Carnarvon display could counter-balance, even if it had not been possible to parallel these with similar differences in other areas where no doubts as to the stratigraphical position of the various beds exist.

IV.—ON THE PALÆOZOIC ROCKS OF NORTH DEVON AND WEST SOMERSET.

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

THE Palæozoic rocks of North Devon and West Somerset, presenting so complete a change in stratigraphical sequence and læontological and lithological characters from those forming the Coal-basins of Somerset and South Wales and their environs, have long attracted the attention of geologists. The bibliography of the subject, which has since attained such formidable dimensions and embraces so many stars in the geological firmament, had been swelled by the contributions of early theorists; and ere the term Grauwacke had been obliterated from our text-books, the general succession of the rocks had been so admirably sketched by De la Beche in his Report that, although too little quoted as an authority on the stratigraphy of the subject, prevalent opinion has now endorsed the correctness of the succession given by him ; and that succession, having been endowed with a recognized nomenclature by subsequent observers, now forms the basis for the discussion of a wider correlation tending almost to sweep away the distinguishing epithets which had been locally applied to its divisions.

The comparison instituted by Mr. Weaver in 1839 between the rocks of North Devon and the South of Ireland opened a controversy which, after the expression of Sir R. Griffith's opinion in 1842, remained tolerably quiescent till 1865, but has since become an almost invariable element in the subsequent treatment of the subject. Prof. Jukes, in 1865, 1866, 1867, and 1868, in a series of papers communicated to the Roy. Geol. Soc. of Ireland and the Geol. Soc. of London, reopened this controversy, maintaining, in opposition to the views of previous writers, that the Lower Culm Measures and Devonian rocks of North Devon were partly correlative with the Carboniferous slates of the South of Ireland, partly with the Old Red Sandstone. He got rid of the obstacles to his theory presented by the great thickness and development of the slate and grit series recognized by Prof. Phillips and others as Middle and Lower Devonian, by the insertion of a great East and West fault between Morthoe and Wiveliscombe; presuming that these strata, in spite of strong lithological and palæontological differences, were a repetition of those on the south of the supposed fault, and regarding the Pickwell Down grits as identical with those of the Foreland Group, and the equivalent of the Old Red Sandstone. This view of the structure of North Devon being so contrary to the then accepted opinion of Prof. Sedgwick and Sir R. Murchison (who advocated a conformable descending series from the Culm Measures, substituting the word Devonian for Transition and Grauwacke before applied to it, and regarding Devonian strata as marine equivalents of the Old Red Sandstone), induced the latter to send Mr. Etheridge to Devon in 1866-7, to vindicate their views. The results arrived at were published in Q.J.G.S. vol. xxviii. in 1867, in the most exhaustive paper that the question has elicited. In it Mr. Etheridge demonstrated the accuracy of the classification put forward by Prof. Phillips in 1841, and endorsed by Mr. T. M. Hall (in a lecture delivered to the Exeter Naturalists' Club in 1866). He pointed out the conformity of the members of the descending sequence, and the absence of any great repeating fault, showing by palæontological evidence that the Middle and Lower Devonian slates could not possibly be a repetition of the Upper Devonian and Lower Culm Measure slates and grits. Mr. Etheridge, however, admitted,[1] that the Pickwell Down Series may be equivalent to the Welsh and Irish Upper Old Red Sandstone. It may therefore be conceded that Prof. Jukes's papers, although entirely at fault as to the stratigraphical and lithological

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[1] Quart. Journ. Geol. Soc. vol. xxviii. p. 688.

structure of North Devon and West Somerset, established a basis for a more philosophical and extended classification. Prof. Hull in 1878 sent an article to the Geol. Mag. in which he accepted Mr. Etheridge's general classification, and Prof. Jukes's correlation of the Pickwell Down Series with the Old Red Sandstone, but regarded the Foreland Group as equivalent to the Dingle and Glengariff grits, bridging over the unconformity between the latter and the Old Red Sandstone by a Marine Devonian series composed of the Morthoe and Ilfracombe slates and shales, the Hangman grits, and the Lynton grits and schists.

In 1879 Prof. Hull read before the Geol. Soc. of London a paper, in which he maintained on evidence the unconformity of the Glengariff grits to the Old Red Sandstone, and the overlap of Carboniferous strata upon them, and correlated the Glengariff grits with the Ludlow series of the West of England and the border of Wales.

In 1880 Prof. Hull further applied his views, correlating the Irish section with that of Devon as proposed by him in 1878, maintaining the identity of the Pickwell Down Sandstones with the Upper Old Red and with the Psammite de Condroz of Belgium, and of the Foreland Grits with the Dingle and Glengariff Beds, as Upper Silurian.

Notwithstanding the vast amount of literature that has been written on North Devon and West Somerset, comparatively little attention has been paid to the stratigraphical relations of the beds apart from considerations of correlation with rocks elsewhere, upon palæontological grounds. Even Mr. Etheridge's paper left much to be done in this respect and failed to explain the changes which the various divisions undergo when traced from west to east, and more particularly left unsolved the relations and extent of the Lower Devonian beds. To supply this need I have neglected no opportunity of ascertaining the relations of the older rocks in North Devon whilst engaged on a survey of the superficial deposits on behalf of the Geological Survey, and, having to study them in West Somerset with reference to the bordering Triassic districts also, succeeded in constructing a geological map of the area upon Sheets 27, 26, 20 and 21, of the Ordnance Maps. Of these, Sheets 20 and 21 have been mapped in detail as well as the defective topography would allow; but in Sheet 27, points of junction, established by coast work and numerous traverses up the courses of the principal streams, have been joined up. Sheet 26 contains a very small part of the Devonian area, and, like 27, has not been surveyed in detail. An abstract of the notes made during these surveys would make a paper of very considerable size, the notes themselves being sufficient to form a monograph upon the stratigraphy of North Devon and West Somerset of considerable bulk. I purpose, therefore, to give the briefest possible outline of the results obtained, taking the divisions *seriatim* from the Foreland rocks upward.

The divisions are as follows:—

Lower Devonian.	Foreland Grits. Lynton Beds—Grits and Schists.

Middle Devonian	Hangman Grits. (Mortehoe and Ilfracombe Series). Slates, Shales, local Gritty Beds and Limestones.
Upper Devonian.	Pickwell Down Grits with Slates. Baggy Beds—Lingula Slates, Cucullæa Grits. Pilton Beds—Argillaceous Slates.

The Foreland grits occupy a superficies of about thirty square miles, extending a distance of seventeen miles from Countesbury on the west to Minehead on the east.

They consist of very hard, generally fine-grained, siliceous, red brown and pale grey grits in thick beds, associated with chocolate red and grey, very hard, irregularly bedded, fine grits, splitting somewhat like marl through a network of close intersecting joints, etc., and very occasionally (as in the valley near Minehead church), assuming a shaly structure.

The Foreland grits are thrown against the Lynton beds by a great fault, shown near the angle of the Foreland projection on the coast, and separated from the point by three spits of gravel beach isolated from the fault, and from each other, by projections of the cliff. In the cliffs the fault is discernible as a thin irregular line of reddish earth, but in their upper and receding portion it is not distinguishable from the beach, probably owing to the presence of a patch of Lynton beds upon the upcast side. In the beach-reefs the fault is evidenced in a direction from E. 15° S. to W. 15° N.; near it, Foreland grits, stained buff and yellow from infiltration, form a conspicuous patch of colour in the cliffs. The fault running inland by Countesbury Camp cuts across the bends in the West Lynn valley on either side of Watersmeet, being shifted a little to the south, by a cross fault at the east end of the Camp. It runs by Hill Farm, Malmsmead, and Oare (*vide* Q.J.G.S. for Aug. 1879, p. 538, etc.).

Patches of Lynton beds appear to rest conformably upon the Foreland rocks, on the north side of this great junction fault at Oare, and probably on the east of Hall Farms, where it appears to be shifted by a cross fault. With the disappearance of the Lynton beds in the East Lynn valley between Oareford and Luccott Hill, it becomes exceedingly difficult to fix on the course of the fault, as the evidence of surface stones and individual sections is not sufficiently marked to distinguish the Foreland from the Hangman series. The fault appears to run from Oareford along the south slope of the valley from Stock Mill to Cloutsham Ball. It is probably shifted by a cross fault on the north of Luckham Barrows, and disappears under the Trias near Old Ball Farm. The Foreland grits reappear at Timberscombe; the main fault, having been shifted to the south, by a cross fault along the Timberscombe valley, runs into the Triassic area near Withycombe, passing by Bonniton (where the Foreland grits make characteristic rounded knoll features) and the north of Dunster Park.

Rocks resembling Foreland grits occur near Parson Farm, on the north margin of the Quantocks, but they may be a variety of the Hangman series.

Lynton Beds.—The Lynton beds occupy an area of about fourteen square miles. They consist of neutral and dark bluish-grey, even-bedded grits, schistose grits and schists, with fossiliferous calcareous films. They pass insensibly upward into the Hangman series. Taking their upper boundary at the coast north of Trentishoe, it trends thence E.S.E., through Martinhoe, by Barbrick Mill, near Brendon Parsonage, along the slope of Oare Oak Hill, and at the base of Black Barrow Down, running into the fault on the north-west of Luccot Hill, where the Lynton beds, near their final disappearance in the East Lynn valley, exhibit a perfectly conformable junction with the overlying Middle Devonian, or Hangman, grits.

Hangman Grits.—The Hangman grits occupy a superficies of about fifty square miles. They are very variable in character, and frequently associated with slaty or shaly beds. The upper part of the division generally consists of rather coarse whitish quartzose grits speckled with red; hard red and grey grits, red finely micaceous grit associated with shaly materials, often characterize the middle portion, whilst lilac and dull-grey grits, sometimes flaggy or slaty, predominate in the lower portion of the division. The variability of this division often renders the site of its faulted junction with the Foreland group between Luccot Hill and Withycombe very indefinite. The features made by the Hangman series are less abrupt than those of the Foreland rocks, and, unlike them, form graceful outlines rising in dominant depressed peaks in the higher districts, as in Dunkery Beacon and the Quantocks, when viewed from a western aspect.

The junction of the Hangman beds with the Middle Devonian slate series, as shown in the cliffs of the Little Hangman Hill bounding Combe Martin Bay, forms a conformable passage through the presence of grits at the base of the latter.

From the coast the junction runs by Holstone, on the north of Paracombe, at the foot of Chapman Barrows, by Oare Oak to the source of the Exe, and thence trends east, at the foot of Black Barrow Down and Codsend Moor. On the east of Luckham Barrows the Hangman beds are apparently cut out by a faulted projection of raddled slates of the overlying series, but they are again brought up by the Timberscombe valley fault, and constitute the major part of Croydon Hill, occurring also in faulted patches on the south of it. They pass under the slate series at the east end of Croydon Hill. Hangman grits form the north part of the Quantocks, extending as far south as Bagborough, but bounded by faulted strips of the slate series between Bagborough and Crowcombe on the margin of the Triassic districts. On the east margin of the Quantocks the slate series wraps round the Hangman beds, being evidenced as far north as Doddington, and in the stream bed by Holford.

The Middle Devonian slate series occupies a superficies of about a hundred and seventy square miles. It forms a band averaging four miles in width from the Woolacombe Sands to Winsford. From Winsford it extends in a faulted northerly projection cutting out the Hangman beds between Croydon Hill and Luckham Barrows. It forms the whole Brendon area east, south-east, and south of Croydon Hill, and the southern part of the Quantocks.

The boundary between the Middle Devonian slates and the Pickwell Down beds has been carefully traced by me throughout the area, with the exception of five miles between West Down and Loxhore, on either side of Bittadon. Near Woolacombe northerly dips in the Middle Devonian (Morte slates) would give colour to Prof. Jukes's supposition of a fault; but they are speedily counteracted, and can only be taken to indicate a local roll or inversion in the beds near their junction which follows the contour. The junction through Smitha Park near Loxhore, is effected by a fault running north-west and south-east for two miles and is probably also a fault where it crosses the Bray Valley near Office Farm. From the coast to Span Head the Pickwell Down beds do not appear to pass lithologically into the Middle Devonian; but from Span Head eastward purple slates make their appearance at the base of the Upper Devonian, and form a perfect passage into the slates of the underlying series (see Proc. Somerset Archæol. and Nat. Hist. Soc. for 1879, part ii. "On the Geology of Parts of Devon and West Somerset north of South Molton, etc.," where the nature of the Middle Devonian slate series and its junction with the Upper Devonian between Challacombe and Lype Hill has been described in detail).

The junction extends by Withypool and Exton Hill to Blagdon Hill, whence, through an anticlinal structure, in part complicated by faults, the Middle Devonian slates extend westward through Brompton Regis to beyond Browford Farm; proving that the great superficial breadth of the Pickwell series between Dulverton Common and Landacre Bridge (near Withypool) is due to flexures. The junction recrosses the Exe and runs along the north flanks of Haddon Down, Heydon Down, and Main Down Hills, finally disappearing under the Triassic rocks on the north of Wiveliscombe.

Morte Slates.—The upper part of the Middle Devonian slate series consists of greenish grey glossy slates, unfossiliferous, and containing much quartz; but in the Brendon Hill area these characters are not persistent, the slates exhibiting bluish grey and silvery hues, and being frequently irregular and gritty.

Ilfracombe Beds.—The lower part of the series is much less homogeneous, being composed of slates and shales with films of arenaceous material and irregular impersistent beds of limestone. The arenaceous element is strongly developed in the Quantock area near Enmore and Asholt, where grits are so abundant as to occasion some difficulty in distinguishing the base of the series from the Hangman division. Grits also occur on the east of Croydon Hill and near Cutcombe.

Limestone bands are most numerous in the vicinity of Combe Martin, and on the Quantocks. Where the calcareous matter was distributed in thin strings or patches, it has frequently been entirely dissolved away, leaving a friable sandstone residuum.

Upper Devonian.—The Pickwell Down series occupies a superficies of about 85 square miles. It is composed of an upper portion of Indian-red-coloured slates upon red, green, and grey grits; the lower beds appear to be greenish and brownish grits, between the coast and Span Head, where the basement series of purple slates makes its appearance. The junction between the Pickwell slates and the green Lingula slates of the Baggy beds is perfectly conformable, being well shown on the coast, and to the south of Loxhore.

Owing to synclinal structure the Pilton and Baggy beds make a re-entering angular projection with the Pickwell Down series on the west of North Molton Ridge. The Pilton and Baggy beds occupy a superficies of about 105 square miles.

The Baggy beds are composed of green slates containing *Lingula*, and brown micaceous grits and flags containing *Cucullæa*. The brown grits extend eastward from the coast to Benton, near Stoke Rivers resting upon the green slates, but further east they are scarcely recognizable as a stratigraphical horizon, the Baggy beds being frequently cut out by faults between Dulverton, North Molton, and East Buckland. Brown grits containing *Cucullæa* occur above the green slates near Witherwind on the south of Haddon Down; but *Cucullæa* has been found by Mr. T. M. Hall in slaty red-brown grits at the base of the green slates in the vicinity of the Tone Valley. As grits occur in the Pilton slates, the *Cucullæa* zone could only be distinguished by the discovery of its characteristic fossils in the district east of Stoke Rivers, whereas the green slates may be regarded as a persistent stratigraphical horizon.

The Pilton beds consist of dull greenish and bluish-grey argillaceous slates, occasionally containing thin strips of calcareous matter generally dissolved away and leaving a brownish friable fossiliferous residuum. They contain a marked development of grits near Braunton, Clayhanger, and Stawley; grits occur also at various horizons in the intermediate localities. The Pilton beds being much plicated, the appearance of grits in them renders the detection of the *Cucullæa* zone in the district between Dulverton and East Buckland very uncertain. Bands of grit running from Hele Bridge, near Dulverton, toward West Anstey, and on the south of North Molton and north of Castle Hill, suggest anticlinal axes of the *Cucullæa* zone.

The Pilton beds make a most unsatisfactory junction with the Culm Measures; they frequently exhibit contrary dips in its vicinity, probably due to inverted anticlinals, and the line where the junction should occur coincides with a strip of old alluvial land cutting across the present north and south courses of the streams, and in part concealed by the alluvium of the River Yeo. Near Dulverton Station the distinction between the Pilton and Culm Measure slates appears to be purely palæontological, and south of Clayhanger and Stawley there is every reason to conclude that their junction is perfectly conformable; at Morebath fault junctions complicate the relations of the beds.

Igneous Rocks.—Notwithstanding the existence of Granite at Lundy, and the appearance of alteration in the Lower Culm Measures of Coddon Hill, etc., igneous rocks are seldom met with in the Palæozoic area of North Devon and West Somerset. Traces of igneous rock occur in the Lower Culm Measures in two or three places near Fremington (Sheet 26). The junction between the

Upper and Middle Devonian was thought to be marked by a reconstructed felsitic rock exposed at Bittadon, where it occupies that position in the series. Professor Bonney, in a recent article in the GEOLOGICAL MAGAZINE, pointed out the intrusive character of this rock as exemplified in the Bittadon section, and with his determination I agree. No long extended line of igneous rock is visible throughout the area, but in the vicinity of the horizon it occupies at Bittadon the rock has been observed in several places. I have observed it near Office Farm on the east of Bray valley (in Sheet 27) at the junction of the Upper and Middle Devonian; and in two places in Sheet 20, between Winsford and Withil Florey, viz. at Armoor Farm in the upper beds of the Middle Devonian slates, and near Farmers Farm in the Middle Devonian at some distance from the Upper Devonian Boundary, its position being probably affected by faults. My friend Mr. Townshend Hall has kindly furnished me with the following additional localities in Sheet 27, viz. between Ashelford and Honeywell Farms, where the felsite was exposed in a well section and road cutting at the junction of the Upper and Middle Devonian; and at Smitha Park in the upper beds of the Middle Devonian near their faulted junction with the Upper Devonian on the east of Loxhore. Sir B. Chichester informed Mr. Hall that he had met with the felsite at Arlington. Between Cockercomb and Adscombe on the Quantocks, Sheet 20, a fine quarry exposes a patch of greenish trap ash rock apparently in faulted basement beds of the Middle Devonian slate series at their junction with the Hangman grits.

In Hestercomb Park (south part of the Quantocks) a patch of syenite occurs in the upper part of the Middle Devonian slate series.

V.—ON SOME POINTS IN THE MORPHOLOGY OF THE RHABDOPHORA.

By JOHN HOPKINSON, F.L.S., F.G.S.

PROFESSOR M'COY, in his "British Palæozoic Fossils" (1854), speaks of transverse diaphragms being present at the base or proximal termination of the calycles (hydrothecæ) of certain graptolites, dividing the calycles from the common canal or perisarc. No further allusion appears to have been made to the presence of any diaphragms or septa until in 1868 the writer mentioned (Journ. Quek. Micros. Club, vol. i.) having observed "an impressed line between the hydrothecæ and the periderm" (perisarc), which was compared with that "at the base of the hydrothecæ in the Sertulariadæ." More recently Professor Allman (Monogr. Tubularian Hydroids, 1872), not admitting the presence of any septum or constriction, has compared the calycles of the Rhabdophora to the nematophores of the Plumularidæ.

A few days ago I examined an extensive collection of graptolites made by Mr. W. Kinsey Dover from the Skiddaw Slates, amongst which are a few specimens from Falcon Crag showing internal structure, most clearly seen in *Didymograptus nitidus* and *patulus*, and *Tetragraptus serra.* In several specimens of these species the thecæ are seen to be separated from the perisarc by a distinctly-marked septum. The perisarc is, moreover, in specimens of all the three species, seen to be jointed, or crossed by transverse septa, there being one septum to each theca. The appearance is therefore that of a common perisarc divided into chambers, from each of which a single isolated hydrotheca is produced. These appearances are not confined to the graptolites of the Skiddaw Slates, having been noticed in well-preserved specimens from the Ludlow Rocks, and, though not so clearly, in specimens from the Lower Silurian Rocks of the South of Scotland.

I have been led to adopt the following conclusions:—that it is owing to the imperfect state of preservation in which graptolites usually occur that the septa are not more frequently seen; that the true interpretation of the appearances presented is that the septa, which seem to completely cut off the hydrothecæ from the perisarc, and the sections of the perisarc from each other, only partially do so, as in the recent Thecaphora; and that these specimens show that the calycles of the graptolites are true hydrothecæ, and do not in any way invalidate the conclusion arrived at from previous investigations into the morphology of the Rhabdophora that they are the Palæozoic representatives of the recent Hydroida.

In Mr. Dover's collection there are also many branches of Didymograpti and Tetragrapti about a foot in length, some showing no signs of termination at either end.

VI.—The Glaciation of the Shetlands.[1]

By David Milne Home, F.R.S.E., F.G.S.

I HAVE read with interest, the reply by Messrs. Peach and Horne in the August Number of the Geological Magazine, to my criticisms on their theory, that the glaciation of the Shetlands is due to a *mer de glace* from Scandinavia.

Will you kindly allow to me space in your Magazine, to acknowledge the courteous terms in which these gentlemen have discussed my criticisms, and to notice, for the information of your readers, the three points on which, as it appears to me, the controversy finally turns.

I. I demurred to the remarkable statement, that, when this gigantic *mer de glace* "abutted" on the Shetlands, coming from the N.E., it "*swung*" or "*veered*" *round* to the N.W. and N.N.W., thus changing its course into one more than a right angle to its previous course.

The explanation of this phenomenon, given by Messrs. Peach and Horne, was, that thereby "it would follow the path of least resistance" (p. 809).

I answered, that if a mass of ice, alleged to be 6000 feet thick and 200 miles wide, could be deflected from its course, by this small cluster of islands, into a new path, viz. "the path of least resistance," that path must have been "along the eastern seaboard of the group, in a direction S. by W., and not across the islands in a N.W. direction."

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[1] Being rejoinder to Messrs. Peach and Horne's reply to Mr. Milne Home's criticisms.

What is Messrs. Peach and Horne's reply? "The deflection along the eastern seaboard, suggested by Mr. Milne Home, is what we believe to have been the case." "But eventually the pressure of the advancing mass was sufficient to compel it to override even the highest hills; and on reaching the mainland, having surmounted the resisting high ground, it naturally (*sic*) veered round to the west" (p. 369).

But towards what direction would "the advancing mass," coming along the eastern seaboard, be pressing? What was there to cause it to *leave* the "path of least resistance" it had taken, and swing round in order to "surmount the high ground of the mainland"?

The pressure of the mighty mass, advancing from the N.E., or rather from N. by E., along the eastern seaboard, would *retain* it in that course, and cause it to avoid any traverse of the islands.

Messrs. Peach and Horne, seeing this, call in the aid of "Scotch ice moving in a N.W. direction, which (they say) must have had a considerable influence in deflecting the Scandinavian *mer de glace* to the N.W." (p. 370).

Where this Scotch ice came from, is not explained;—and of its existence, not the slightest evidence is given. But it is not in the least likely, that any paltry mass of ice generated in the north of Scotland could, by passing into the North Sea, and encountering the Scandinavian monster moving along the Shetland seaboard, have power to turn it, and force it into another course at right angles to its previous course.

II. The evidence on which Messrs. Peach and Horne seek to show that their *mer de glace* was again deflected, and made to cross the islands in a N.W. direction, consists of *boulders* and *rock striations.*

1. In regard to boulders, many of which (it was said) were "carried from the lower to the higher levels;—indeed carried to the highest hills," in virtue of "the westerly movement of the great *mer de glace*" (p. 804), I asked:—

(1). Whether "the effect of such an agency would not rather be to sweep off from ridge and hill-top every particle of rubbish, and leave no boulders on them?" (p. 211).

To this inquiry, Messrs. Peach and Horne reply, "that some of the boulders were borne forward in the ground moraine; while others became fixed in the lower portion of the ice-sheet, and were likewise carried forward by the advancing mass. As the ice melted backwards, the rocks and angular *débris* were stranded at the localities where we now find them, except where displaced by later movements" (p. 372).

Boulders can no doubt be "carried forward" by a mass of ice; but if left by the ice, when either "advancing" or "melting backwards," it would not be on ridges or hill-tops, but in the valleys through or over which the ice passed.

But the Shetland group consists of *islands*, separated by sea sounds, some of them many fathoms deep and many miles wide. Across these sounds, as well as the islands, the *mer de glace* is said to have passed; and in doing so, any boulders carried by it must have been left in the depths of these sounds, instead of being "carried to the hills."

(2). Messrs. Peach and Horne, in their original paper, laid great stress on the fact that all the boulders, and especially those on the west shores of the islands, came from the eastward. No reference was made to boulders which previous observers had discovered, and had traced to quarters quite at variance with the alleged course of the *mer de glace.*

These boulders are on Papa Stour, Foula, Hilswick, and Roeness. In no case, do Messrs. Peach and Horne deny that these boulders exist, or dispute that they came in the directions pointed out.

Messrs. Peach and Horne do not and cannot say, that they could have been transported by their *mer de glace.* Their Memoir and Map alike forbade such a suggestion. A different agency altogether, therefore, must be thought of for them.

(3). Then there is the distinct record of observations by Mr. Peach (*senior*), which are equally at variance with the *mer de glace* theory. True, Mr. Peach has been so obliging as to grant a letter stating that he has now changed his opinion as to the direction of the drift in Unst, *in consequence of having since seen and thought more of the glaciation of Scotland.* His *opinion* he was at liberty to change. His published record of *facts* he cannot, and I am sure will not change; and it is one of these facts that, when he ascended Heog Hill, he *found* "the W.N.W. *end* vertical and *polished* to the depth of at least 500 feet;" and which W.N.W. end, he afterwards describes as "the *storm* side of the hill," which had "*evidently resisted a portion of the destroyer*, and turned the greater part of, on its western flank."

These are facts about which a man of Mr. Peach's experience, intelligence, and scrupulous accuracy, could not be mistaken; and these facts are also entirely in discordance with the Scandinavian theory, and the statements of Messrs. Peach and Horne.

(4). I hope these gentlemen will forgive me for saying, that I am amused at their "adducing the testimony of Mr. Milne Home regarding Norwegian boulders in Shetland,"—implying that I had attested the presence of such boulders there. Messrs. Peach and Horne, on referring to the Report of the Edinburgh Royal Society Boulder Committee, must no doubt have perceived, that the schoolmaster who wrote to the Committee about boulders in Bressay, merely mentioned that "they were *conjectured* to have come from Norway." Messrs. Peach and Horne must have felt rather hard up for support to their theory, when they adduce a conjecture by some unknown Shetlander, as "the testimony of Mr. Milne Home."

2. Having now adverted to the evidence which *boulders* afford of "the (alleged) movement of an ice-sheet across the islands from the North Sea to the Atlantic" (p. 790), I next notice the help sought to be obtained from *rock striations.*

(1). In my original paper, I stated that I placed little value on *striæ*, unless they themselves indicated the direction in which the striating agent had moved. Thus, in reference to N.W. and S.E.

markings, which Messrs. Peach and Horne founded on as indicating a movement from the S.E., I observed, that "the evidence to show that the movement was from the S.E., and not from the N.W., was not given" (Address 35).

Messrs. Peach and Horne expressed surprise at this remark, as the boulders, being in their opinion transported by the same agent which striated the rocks, afforded the evidence asked for.

What I meant was, that not unfrequently *striæ* themselves indicate by their incision on the rock, which end had first been formed. Where a striation shows a wide or deep marking at one end, and a gradual disappearance towards the other end, the presumption is that the striating agent had begun its work at the first-mentioned end.

Not one of the striations mentioned by Messrs. Peach and Horne appeared to have presented these indications, and therefore I attached little value to them. Accordingly, after adverting to what I supposed to be the true bearings of those mentioned by Mr. Peach (*senior*), I went on to say, that "*the more material point*" was, that Mr. Peach, when he discovered which was the "*polished*" and "*storm*" side of Heog Hill, at once saw the direction in which the agent had moved, carrying the drift and striating the rocks.

(2.) Messrs. Peach and Horne have pointed out that, in converting Mr. Peach's magnetic into true bearings, I committed an arithmetical mistake. I admit and regret it. Mr. Peach's bearings having been W.N.W.—I should have stated the true bearings to be E. and W., and not N.W.

But the mistake is wholly immaterial, and indeed irrelevant, as regards the question at issue, which is, whether the drift came across the Island of Unst from the *eastward* or from the *westward*. Messrs. Peach and Horne, alike in Map and Memoir, assert that it came from the eastward. Mr. Peach (*senior*) saw what satisfied him that it came from the westward. Messrs. Peach and Horne admit this, when (in their last paper) they say (p. 365), "The ice which produced these markings, must have come from east or west. Mr. Peach inferred that the movement had been from the west."

That is sufficient for my argument. It is not of the slightest consequence, whether the movement was from due W., or W.N.W., or N.W.; and therefore I was less careful in calculating the exact westerly bearings.

(3.) Another circumstance is now mentioned by Messrs. Peach and Horne in their last paper, which shows how little reliance is to be placed on the direction of the striations observed by them. They state that in the Island of Unst, "as there was a strong local deflection of the compass, amounting to about 25°, the proper direction of the striations was obtained from a party of the Ordnance Survey, who were at work near the spot at the time they were noted" (p. 366).

This seems to me a circumstance seriously affecting the dependence to be placed on any of the striations recorded by Messrs. Peach and Horne. How they discovered the fact of there being a local compass deflection at the place named, is not explained. But similar large deflections may exist elsewhere, and without these gentlemen having been aware of them.

Before concluding these remarks on the subject of rock striations, may I venture to suggest, that there should be a re-examination, with the view of ascertaining whether many, or any of them, give indications of the ends which were first cut in the rock. During the last two years, I have found many examples, notice of which may be seen in the Reports of the Edinburgh Royal Society Boulder Committee. If the deepest incisions in the Western Islands of the Shetlands are at the S.E. ends, they will verify the views of Messrs. Peach and Horne. If at the N.W. ends, they will justify the doubts and criticisms which I have presumed to offer.

III. On a review of the whole evidence which Messrs. Peach and Horne have adduced in support of the Scandinavian *mer de glace* theory, I have only to say, that the more the matter is discussed, the more difficult it appears to me to support it.

The idea of an immense mass of ice, with an alleged thickness of 6000 feet, a length of 400 miles, and 200 miles in width, sliding over the bottom of the North Sea, and whenever it reached the Shetlands, *swinging* out of its natural course, to follow a new path at right angles to its previous course, seems to me utterly inconsistent alike with precedent and principle; and the evidence by which this phenomenon is sought to be established, as might have been anticipated, entirely fails. The boulders, instead of showing transport in accordance with the supposed march of this *mer de glace*, show transport irreconcileable with it. The rock striations founded on are also so discordant, that I must express my surprise at the assertion of Messrs. Peach and Horne that "the islands have been grooved and "striated in one determinate direction" (p. 808). On the contrary, it seems to me undeniable that the directions of the striæ, not only on the different islands, but on the same island, and at places not far from one another, are most diverse and contradictory; some proof of which is afforded by the ingenious but inadmissible conjectures offered to explain them.

In short, it appears to me that the circumstances brought out by the Memoirs of Messrs. Peach and Horne, have made out a very strong case for the theory of floating ice moved by tides and winds, as in that way it is possible to explain how fragments of rock were carried from one island to another, and at the same time striations made on the rocks in different directions.

There are, however, strong grounds for believing that at the time of the Boulder transport, a current prevailed in the North Atlantic from the N.W., and therefore I am not surprised that the striations of the rocks on the western seaboard of the Shetlands should run in a direction N.W. and S.E., as Messrs. Peach and Horne state.

That also is the direction of the striæ in the Hebrides, and on the coasts of Argyllshire facing the Atlantic;—and in all these cases the striating agent has been shown to have come from the N.W.

In concluding my review of these Memoirs, I wish in all sincerity to repeat my regret, should Messrs. Peach and Horne feel annoyed at the doubts I have expressed, and which I still entertain, as to the soundness of their speculations. In the interest of geological science, it is desirable, when new and startling theories are propounded, for which public acceptance is claimed, and especially when emanating from quarters entitled to respect, that some one should step forward to weigh the evidence on which these theories rest. Though there are many others who would have discharged this duty much more satisfactorily than myself, still it seemed to me not incompatible with the position I have the honour to hold as President of the Edinburgh Geological Society, to undertake that duty.

VII.—On some Differences between the London and Berlin Specimens referred to *Archæopteryx*.

By Prof. H. G. Seeley, F.R.S., etc.

(PLATE XII.)

In drawing attention to some characters of the Berlin *Archæopteryx*, it should be stated that I only know that specimen from a photograph taken before the slab was fully developed; and therefore while I believe the following results to be trustworthy as indicating specific and it may be generic differences, it is possible they may hereafter be slightly modified.

As stated by Vogt, the Berlin slab is ⅕th smaller than the London slab; assuming the photograph to be of natural size, the following measurements may demonstrate the nature of the relation between the two specimens. The femur measures in the Berlin slab 4·8 centim.; in the London slab 6 centim., so that the London specimen is ⅕th longer. The tibia in the Berlin slab measures 6·8 cm.; in the London slab it is 8 cm. Therefore in the latter the femur is ¾ths the length of the tibia; but if this proportion obtained in the Berlin specimen, the femur would have measured 5·1 cm.: hence the second specimen is slightly longer-legged. In the metatarsus the difference is nearly ⅕th, for the Berlin animal measures 3·5 cm., and the London type 4·4 cm. The digits of the Berlin specimen measure respectively 1·5; 2·9; 3·1 cms.; the measurements in the London specimen are 1·7; 3·5; and 4·5 cms.; so that the longest digit of the London slab is more than a third longer than the corresponding digit of the Berlin slab. Hence in the latter animal the foot is relatively shorter and the drumstick relatively longer.

In the fore-limb the Berlin humerus measures 5·9 cm., the London humerus 7 cm.; the difference is between a sixth and a seventh. The Berlin ulna measures 5·1 cm.; the London ulna 6·7 cm.; the difference is a little less than a fourth, but while the Berlin humerus is about a seventh longer than the ulna, the London humerus is only about a twenty-third longer than the ulna. This difference is more marked than that between the tibia and femur, and shows that the fore-arm was relatively longer in the Berlin animal. The difference in the metacarpus is about one-fifth, the Berlin measurement being 2·7 cm., the London measurement 3·4 cm. Only two digits can be

G. M. Woodward del. et lith. West Newman & C° imp.

Archæopteryx macrura, Owen.
Lithographic Stone, Solenhofen, Bavaria.
(Original in the Berlin Museum.)

compared; in the London slab they measure 2·5 cm. and 2·9 cm.; in the Berlin slab 1·7 and 2·8, but the longest Berlin digit is 4·3 cm.; so that notwithstanding its smaller size the Berlin animal appears to have had digits as long as the London specimen. The Berlin scapula measures 4 cm. and may be imperfect; the London scapula is 4·2 cm. The London ilium is 4·3 cm. long, in the Berlin slab it does not appear to exceed 3 cm. The ribs appear to be longer in the Berlin slab, some measuring 4·8 cm., while the longest in the London slab is 3·7 cm.

The Berlin tail measures 16·5 cm., and appears to include 21 vertebræ; the London tail measures 20·8 cm., and appears to include 23 vertebræ, of which the first 9 have transverse processes. The London animal probably had 5 sacral and 8 dorsal vertebræ, with a length of 8·5 cm., though number and length are uncertain. In the Berlin animal the length of this region is 8·5 cm. Vogt counts 10 in the back. The neck is imperfect in the London slab, the vertebræ lie in curve, five at least are preserved; a centrum measures 1 cm. In the Berlin slab the neck measures about 6·8 cm. Vogt estimates 8 vertebræ, but there are probably more. The head of the London animal as preserved measures 4 cm. in length; the Berlin head to the occipital articulation is 4·7 cm., and to the limit of the occipital crest about 6·1 cm. These differences are supported by details in the forms of the bones, which also prove the species to be distinct.

NOTICES OF MEMOIRS.

I.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, FIFTY-FIRST MEETING, 31ST AUGUST, 1881.

[Sir JOHN LUBBOCK, Bart., M.P., D.C.L., LL.D., F.R.S., etc., *President.*]

1.—TITLES OF PAPERS READ IN SECTION C. (GEOLOGY).

President: Professor A. C. RAMSAY, LL.D., F.R.S., etc.

Address by the President. (See p. 459.)

Prof. E. Hull, LL.D., F.R.S.—On the Laurentian Beds of Donegal and of other parts of Ireland.

G. H. Kinahan, M.R.I.A.—On the Laurentian Rocks of Ireland.[1]

C. Moore, F.G.S.—Life in Irish and other Laurentian Rocks.

A. R. Hunt, M.A., F.G.S.—On the Occurrence of Granite *in situ* about 20 miles S.W. of the Eddystone.

Professor J. Prestwich, M.A., F.R.S.—Some observations on the causes of Volcanic Action.

Professor W. J. Sollas, M.A., F.G.S.—The connexion between the Intrusion of Volcanic Rocks and Volcanic Eruptions.

Baldwin Latham, M. Inst. C.E., F.G.S.—On the Influence of Barometric Pressure on the Discharge of Water from Springs.

J. E. Clark, B.Sc.—Glacial Sections at York.

G. W. Lamplugh.—On the Bridlington and Dimlington Glacial Shell Bed.

J. R. Mortimer.—On Sections of the Drift obtained by the new drainage works of Driffield.

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[1] See GEOL. MAG. Sept. p. 427.

A. G. Cameron.—On Subsidences over the Permian Limestone between Hartlepool and Ripon.

J. D. Kendall.—The Glacial Deposits of West Cumberland.

Professor H. G. Seeley, F.R.S.—On *Simosaurus pusillus* (Fraas), and the evolution of Plesiosaurus.

Professor H. G. Seeley, F.R.S.—On a restoration of *Archæopteryx*, with remarks on differences between the two specimens. (See p. 454.)

Professor P. M. Duncan, F.R.S.—On *Asterosmilia Readi*, a new Species of Coral from the Oligocene of Brockenhurst.

Professor J. Prestwich, M.A., F.R.S.—On the strata between the Chillesford Beds and the Lower Boulder Clay—"The Mundesley and Westleton Beds."

Professor J. Prestwich, M.A., F.R.S.—On the Extension into Essex, Middlesex, and other inland counties of the Mundesley and Westleton Beds, in relation to the Age of certain Hill Gravels, and of some of the Valleys of the South of England. (See p. 466.)

E. B. Poulton, M.A.—A Preliminary Report of the working (now in progress) of Dowkerbottom Cave, in Craven.

C. E. De Rance.—Report on the Circulation of Underground Waters.

W. H. Baily.—Report on the Tertiary Flora of the Basalt of the North of Ireland.

E. Wethered.—On the Formation of Coal. (See p. 469.)

Professor W. C. Williamson, F.R.S.—Preliminary Remarks on the Microscopic Structure of Coal.

W. Cash.—Some Remarks on the Halifax Hard Seam.

Jas. Spencer.—Researches in Fossil Botany.

Jas. Spencer.—Notes on *Astromyelon* and its root.

W. A. E. Ussher.—On the Palæozoic Rocks of North Devon and West Somerset. (See p. 441.)

Professor E. Hull, F.R.S.—The Devono-Silurian Formation.

Rev. E. Hill, M.A.—On Evaporation and Eccentricity as Cofactors in the causes of Glacial Periods.

A. Strahan.—On the Discovery of Coal-measures under New Red Sandstone, and on the so-called Permian Rocks of St. Helen's, Lancashire. (See p. 433.)

E. B. Tawney, M.A.—On the Upper Bagshot Sands of Hordwell Cliffs, Hampshire.

Rev. H. W. Crosskey.—Report on the Erratic Blocks of England, Wales, and Ireland.

G. R. Vine.—Report on Fossil Polyzoa. (See p. 471.)

J. R. Dakyns, M.A.—On "Flots."

P. H. Carpenter, M.A.—Remarks on the Structure and Classification of the Blastoidea. (See p. 464.)

P. H. Carpenter, M.A.—On the Characters of the Lansdowne Encrinite, *Millericrinus Prattii*, Gray. (See p. 466.)

A. Strahan, M.A.—On the Lower Keuper Sandstone of Cheshire.[1]

E. Wilson.—On a Discovery of Fossil Fishes in the New Red Sandstone of Nottingham.

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[1] See Geol. Mag. September, p. 396.

E. Wilson.—On the Rhætics of Nottinghamshire. (See p. 464.)

W. T. Blanford, F.R.S.—The Great Plain of Northern India not an Old Sea Basin.

W. King, B.A.—On Gold in Southern India, and the Quartz Outcrops.

R. Russell.—On the Geology of the Island of Cyprus.

Professor E. Hull, LL.D., F.R.S.—Observations on the two types of Cambrian Beds in the British Isles (the Caledonian and the Hiberno-Cambrian), and the conditions under which they were respectively deposited.

Professor T. McK. Hughes, M.A. — On the Lower Cambrian of Anglesea.

Professor T. McK. Hughes, M.A.—On the Gnarled Series of Holyhead and Amlwch in Anglesea.

Professor W. J. Sollas, M.A.—The Subject-matter of Geology and its Classification.

J. W. Davis.—An Account of the Exploration of the Raygill Fissure in Lothersdale, Yorkshire.

J. W. Davis.—On *Diodontopsodus,* a new genus of Fossil Fishes from the Mountain Limestone of Yorkshire.

J. W. Davis.—On the Zoological Position of the genus *Petalorhynchus,* Agass., Fossil Fishes from the Mountain Limestone.

Professor John Milne.—Report on the Earthquakes of Japan.

Professor John Milne and Thomas Gray, B.Sc.—A Contribution to Seismology.

Professor A. S. Herschel, M.A., and Professor G. A. Lebour, M.A.—Report on the Thermal Conductivities of certain Rocks, showing especially the Geological Aspects of the Investigation. (Read also before Section A.)

W. Topley.—On an International Scheme of Colours for Geological Maps.

J. A. Phillips, F.R.S.—The Origin of Desert Sandstone.

W. Keeping, M.A.—On the Glacial Geology of Central Wales.

J. Hopkinson.—On some points in the Morphology of the *Rhabdophora,* or true Graptolites. (See p. 448.)

H. Stopes.—On some Ores and Minerals from Laurium, Greece.

C. E. De Rance.—Notes on the Cheshire Salt Field.

J. E. Marr.—On some Sections in the Lower Palæozoic Rocks in the Craven District.

2.—TITLES OF PAPERS, BEARING UPON GEOLOGY, READ IN OTHER SECTIONS.

SECTION A.—PHYSICAL SCIENCE.

Dr. S. Haughton.—On the Effects of Gulf Streams upon Climates.

Professor Schuster.—Report of Committee on Meteoric Dust.

J. N. Shoolbred.—Report of Committee on Tidal Observations in the English Channel and the North Sea.

Professor Everett.—Report of Committee on Underground Temperature.

T. Fairley.—On the Blowing Wells at Northallerton. (Read also before Section B.)

Sir Wm. Thomson.—On the Thermodynamic Acceleration of the Earth's Rotation.

SECTION B.—CHEMICAL SCIENCE.

I. Lowthian Bell, F.R.S.—On the Occlusion of Gaseous Matter by Fused Silicates at high temperatures, and its possible connexion with Volcanic Agencies.

W. Lant Carpenter, B.A., B.Sc.—On the Siliceous and other Hot Springs in the Volcanic Districts of the North Island of New Zealand.

V. H. Veley, B.A.—The Oxides of Manganese.

J. Y. Buchanan.—On Manganese Nodules and their Occurrence on the Sea Bottom.

E. Divers, M.D.—Note on the Sodium Alum of Japan.

E. Divers, M.D.—Note on the Occurrence of Selenium and Tellurium in Japan.

E. Divers, M.D.—Note on the Chrome Iron Ore of Japan.

J. A. Wanklyn.—Note on the Phosphates of Lime and Ammonia.

W. Galloway.—On Colliery Explosions.

C. F. Cross, B.Sc., and E. J. Bevan.—Cellulose and Coal.

J. L. Phipson.—On the New Metal Actinium.

SECTION D.—BIOLOGY.

R. J. Ussher.—Report on the Caves and Kitchen-middens at Cappagh, Co. Waterford.

Professor O. C. Marsh.—Jurassic Birds and their Allies.

General Pitt-Rivers, F.R.S.—On the Discovery of Flint Implements in Stratified Gravel in the Valley of the Nile, near Thebes.

Thomas Hicks and W. Cash.—On a Fossil Stem from the Halifax Coal-measures.

H. Stopes.—Traces of Man in the Crag.

Professor T. McK. Hughes and A. Williams Wynn.—On the Age of the Deposits in the Caves of Cefn, near St. Asaph, with special reference to the date of Man's First Appearance in them.

Henry Seaton Harland.—On Prehistoric Flints, etc., lately found whilst excavating on the New Line of Railway from Pickering to Scarborough.

SECTION E.—GEOGRAPHY.

W. Lant Carpenter, B.A., B.Sc.—On the Hot-Lake District, and the Glaciers and Fjords of New Zealand.

Commander V. L. Cameron, R.N.—Recent Visit to the Gold Mines of the West Coast of Africa.

SECTION G.—MECHANICAL SCIENCE.

Joseph Lucas.—On an Organization for the Systematic Gauging of the Wells, Springs, and Rivers of Great Britain.

II.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. JUBILEE MEETING, YORK. Address to the Geological Section by the President, A. C. Ramsay, LL.D., F.R.S., etc., Director-General of the Geolgical Survey, September 1st, 1881.

ON THE ORIGIN, PROGRESS, AND PRESENT STATE OF BRITISH GEOLOGY, ESPECIALLY SINCE THE FIRST MEETING OF THE BRITISH ASSOCIATION AT YORK IN 1831.

IN the year 1788, Hutton published his first sketch of his "Theory of the Earth," afterwards extended and explained by Playfair in a manner more popular and perspicuous than is done in Hutton's own writings. In this grand work, Hutton clearly explains that the oldest known strata, like their successors, are derivative, and that as far as *observation* can discover, in all geological time, "we find no vestige of a beginning, and no sign of an end." The complement to this far-seeing observation was at length brought about by William Smith, in his original "Geological Map of the Strata of England and Wales" in 1815, followed, in 1816, by his "Strata Identified by Organized Fossils." This great discovery, for such it was, threw a new light on the history of the earth, proving what had before been unknown, that all the "Secondary" formations at least, from the Lias to the Chalk inclusive, contained each a set of distinctive fossils by which it could be recognized. A law was thus provided for the identification of formations which geographically are often widely separated from each other, not only in England in the case of minor outliers, but also easily applicable to great areas on the neighbouring continent of Europe.

In 1811, the first volume of the "Transactions" of the Geological Society was published, and in 1826–27, there appeared the first volume of the "Proceedings," the object being to communicate to the Fellows as promptly as possible the proceedings of the Society "during the intervals between the appearance of the several parts of the Transactions." The last volume of the "Transactions" contains memoirs read between the years 1845–1856, and only four volumes of the "Proceedings" appeared between the years 1826 and 1845 inclusive, after which the title of the annual volume was changed to that of the "Quarterly Journal of the Geological Society." The Geological Society, to which the science owes so much, was therefore in full action when the British Association was founded in 1831, and the memoirs read before the Society from 1831 to this date may be said to show generally the state of British geology during the last fifty years. To this must be added the powerful influence of the first (1830) and later editions of Lyell's "Principles of Geology," a work which helped to lay the foundations of those researches in Physical Geology which both in earlier and later years have attracted so much attention.

Fifty years ago in this city, Viscount Milton was President of the first meeting of "The British Association for the Advancement of Science," which he explained had for its chief object "to give a stronger impulse and more systematic direction to scientific inquiry."

In his address, he pointed out the numbers of Philosophical Societies which by degrees sprung up in all parts of the kingdom; and the practicability, through the means of the Association, "including all the scientific strength of Great Britain," "to point out the lines in which the direction of science should move."

In that year, 1831, Professor Sedgwick was president of the Geological Society, and the Geological and Geographical Committee of the British Association recommended that geologists should examine the truth of that part of the theory of Elie de Beaumont, in its application to England, Scotland, and Ireland, which asserts that *the lines of disturbance of the strata assignable to the same age are parallel;* that Professor Phillips be requested to draw up *a systematic catalogue of all the organized fossils of Great Britain and Ireland;* and that Mr. Robert Stevenson, Civil Engineer, be requested to prepare a report upon *the waste and extension of the land on the east coast of Britain, and the question of the permanence of the relative level of the sea and land.*

In 1881 it seems strange to us that, in 1831, with William Smith's map of "The Strata of England and Wales, with part Scotland," before them, it should have been considered necessary to institute an inquiry as to the truth of the general parallelism of disturbed strata, which, in a limited area like England, had suffered upheaval at different successive epochs; and we may fancy the internal smile with which Phillips, the nephew of Smith, regarded the needless proposal. The masterpiece of the old land surveyor and civil engineer remains to this day the foundation of all subsequent geological maps of England and Wales; and *as an unaided effort of practical genius*—for such it was—it seems impossible that it should be surpassed, in spite of all the accuracy and detail which happily modern science has introduced into modern geological maps.

The first paper read at York, in the year 1831, was by Professor Sedgwick, "On the general structure of the Mountains of the North of England." This was followed by "Supplementary Observations on the Structure of the Austrian and Bavarian Alps," by the Secretary of the Society, Mr. Murchison, a memoir at that time of the highest value, and still valuable, both in a stratigraphical point of view, and also for the light which it threw on the nature of the disturbances that originated the Alpine mountains, and their relations in point of date to the far more ancient mountains of Bohemia. In his elaborate address in the same year, on his retiring from the President's chair, he largely expatiates on the parallelism of many of the great lines of disturbance of what were then distinguished as the more ancient *schistose* and *greywacké* mountains, and quotes the authority of Elie de Beaumont for the statement, "that mountain chains elevated at the same period of time, have a general parallelism in the bearing of their component strata." On a great scale this undoubtedly holds true, as, for example, in the case of the Scandinavian chain, and the more ancient Palæozoic rocks north of Scotland, Cumberland, and even of great part of Wales. The same holds good with regard to the parallelism of the much more recent mountain ranges of the Apennines, the Alps, the Caucasus, the Atlas, and the Himalaya, all of which strike more or less east and west, and are to a great extent of Post-Eocene, and even partly of Post-Miocene age. The same, however, is not precisely the case with the Appalachian chain, and the Rocky Mountains of North America, the first of which trends N.N.W., and the latter N.N.E. The remarkable chain of the Ural Mountains trends nearly true north and south, and is parallel to no other chain that I know of, unless it be the Andes and the mountains of Japan. It is worthy of notice that the chain of the Ural is of Pre-Permian age according to Murchison, while Darwin has shown that the chief upheaval of the Andes took place in Post-Cretaceous times.

The Appalachian chain is chiefly of Post-Carboniferous date, and the Rocky Mountains have been re-disturbed and re-elevated as late as Post-Miocene times.

In the same address Professor Sedgwick entered an eloquent protest against the broad uniformitarian views so powerfully advocated in the first edition of Lyell's "Principles of Geology" in 1830, in which, throwing aside all discussion concerning cosmogony, he took the world as he found it, and, agreeing with Hutton, that geology is in no way concerned with, and not sufficiently advanced to deal "with questions as to the origin of things," he saw that a great body of new data were required such as engaged the attention of the Geological Society (founded in 1807), and which along with other foreign societies and private work has at length brought geological science to its present high position.

And what is that position? With great and consistent labour many men gifted with a knowledge of stratigraphical and palæontological geology, have, so to speak, more or less dissected all the regions of Europe and great part of North America, India, and of our colonies, and in vast areas, sometimes nearly adjoining, and sometimes far distant from each other, the various formations, by help of the fossils they contain, have been correlated in time, often in spite of great differences in their lithological characters. It is easy, for example, to correlate the various formations in countries so near as Great Britain and Ireland, or of the Secondary and Lower Tertiary formations of England and France; and what is more remarkable, it is easy to correlate the Palæozoic formations of Britain and the eastern half of the United States and Canada, even in many of the comparatively minute stratigraphical and lithological subdivisions of the Silurian, Devonian, and Carboniferous formations. The same may be said with regard to some of the Palæozoic formations of India, China, Africa, and Australia, and many of the Secondary and Tertiary deposits have in like manner been identified as having their equivalents in Europe. It is not to be inferred from these coincidences that such deposits were all formed *precisely* at the same time, but taken in connection with their palæontological contents, viewed in the light which Darwin has shown with regard to the life of the globe when considered in their relation to masses of stratified formations, no modern geologist who gives his mind to such subjects would be likely to state, for example, that in any part of the globe Silurian rocks may be equivalents in time to any of our Upper Palæozoic, Mesozoic, or Tertiary formations.

For all the latest details of genera and species found in the British Palæozoic rocks, from those of St. Davids, so well worked out by Dr. Hicks, to the Carboniferous series inclusive, I must refer to the elaborate address of Mr. Etheridge, President of the Geological Society, which he delivered at the last anniversary meeting of that Society. It is a work of enormous labour and skill, which could not have been produced by any one who had not a thorough personal knowledge of all the formations of Britain and of their fossil contents.[1]

In connection with such subjects I will not in any way deal with the tempting and important subject of cosmological geology, which in my opinion must go back to times far anterior to the date of the deposition, as common sediments, of the very oldest known metamorphic strata. Cosmological speculations perhaps may be sound enough with regard to refrigeration, and the first consolidation of the crust of the earth, but all the known tangible rocky formations in the world have no immediate relation to them, and in my opinion the oldest Laurentian rocks were deposited long after the beginning and end of lost and unknown epochs, during which stratified rocks were formed by watery agents in the same way that the Laurentian rocks were deposited, and in which modern formations are being deposited now, and the gneissose structure of the most ancient formations was the result of an action which has at intervals characterized all geological time as late as the Eocene formations in the Alps and elsewhere.

The same kind of chronological reasoning is often applicable to igneous rocks. It was generally the custom, many years ago, to recognize two kinds of igneous rocks, viz. Volcanic and Plutonic, and this classification somewhat modified in details is still applicable, the Plutonic consisting chiefly of granitic rocks and their allies, and which, though they have often altered and thrust veins into the adjoining strata, have never, as far as I know, overflowed in the manner of the lavas of modern and ancient volcanoes. Indeed, as far as I recollect, the first quoted examples of ancient volcanoes are those of Miocene age in the districts of Auvergne, the Velais, and the Eifel, and the fact that signs of ordinary volcanic phenomena are found in almost all the larger groups of strata was scarcely suspected. Now, however, we know them to be associated with strata of all or almost all geological ages, from Lower Silurian times down to the present day, if we take the whole world into account. Amongst them, those of Miocene date hold a very prominent place, greatly owing, doubtless, to the comparative perfection of their forms, as, for example, those of the South of France and of the Eifel. Their conical shapes, and numerous extinct craters, afford testimony so plain, that he who runs may read their history.

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[1] I must also, with much pleasure, advert to Prof. Prestwich's inaugural lecture when installed in the Chair of Geology at Oxford in 1875, the subject of which is "The Past and Future of Geology."

The time when they became extinct would doubtless amaze us by its magnitude, if it could be stated in years, but yet it is comparatively so recent that not all the undying forces of atmospheric degradation have heen able to obliterate their individual origin.

It is, however, generally very different with respect to volcanoes of Mesozoic age, for, though Lyell stated with doubt, that volcanic products of Jurassic date are found in the Morea, and in the Apennines; and Medlicott and Blanford consider that probably the igneous rocks of Rajmahal may be of that age, we must, perhaps, wait for further information before the question may be considered as finally settled. Of Jurassic age no actual craters remain. Darwin also has stated, on good grounds, that in the Andes a line of volcanic eruptions has been at work from before the deposition of the Cretaceo-Oolitic formation down to the present day.

In the British Islands we have a remarkable series of true volcanic rocks, the chronology of which has been definitely determined. The oldest of these belongs to the Lower Silurian epoch, as shown, for example, on a large scale in Pembrokeshire, at Builth in Radnorshire, in the Longmynd country west of the Stiper stones in Shropshire, and on a far greater scale in North Wales and Cumbria. Of later date we find volcanic lavas and ashes in the Devonian rocks of Devon, and in the Old Red Sandstone of Scotland. The third series is plentiful among the Carboniferous rocks of Scotland, and in a smaller way interstratified with the Coal-measures of South Staffordshire, Warwickshire, and the Clee Hills. The fourth series chronologically is associated with the Permian strata in Scotland, and the fifth and last consists of the Miocene basaltic rocks of the Inner Hebrides and the mainland of the West of Scotland.

In the British Islands the art of geological surveying has, I believe, been carried out in a more detailed manner than in any other country in Europe, a matter which has been rendered comparatively easy by the excellence of the Ordnance Survey Maps both on the 1-inch and the 6-inch scales. When the whole country has been mapped geologically, little will remain to be done in geological surveying, excepting corrections here and there, especially in the earliest published maps of the South-west of England. Palæontological detail may, however, be carried on to any extent, and much remains to be done in microscopic petrology which now deservedly occupies the attention of many skilled observers.

Time will not permit me to do more than advert to the excellent and well-known geological surveys now in action in India, Canada, the United States, Australia, New Zealand, and South Africa.

On the Continent of Europe there are National Geological Surveys of great and well-deserved repute, conducted by men of the highest eminence in geological science; and it is to be hoped the day may come when a more detailed survey will follow the admirable map executed by Sir Roderick Murchison, De Verneuil, and Count Keyserling, and published in their joint work, "The Geology of Russia in Europe and the Ural Mountains."

It is difficult to deal with the Future of Geology. Probably in many of the European formations, more may be done in tracing the details of subformations. The same may be said of much of North America, and for a long series of years a great deal must remain almost untouched in Asia, Africa, South America, and in the islands of the Pacific Ocean. If, in the far future, the day should come when such work shall be undertaken, the process of doing so must necessarily be slow, partly for want of proper maps, and possibly in some regions partly for the want of trained geologists. Palæontologists must always have ample work in the discovery and description of new fossils, marine, freshwater, and truly terrestrial; and besides common stratigraphical geology, geologists have still an ample field before them in working out many of those physical problems which form the true basis of Physical Geography in every region of the earth. Of the history of the earth there is a long past, the early chapters of which seem to be lost for ever, and we know little of the future except that it appears that "the stir of this dim spot which men call earth," as far as Geology is concerned, shows "no sign of an end."

III.—On the Rhætics of Notts. By E. Wilson, F.G.S.

THE author gave a summarized account of the Rhætic series in Nottinghamshire. The Rhætic sections of this district already known to geologists comprise those at Gainsboro', Newark, and Elton. The author described several additional new sections in the Rhætics of the county—viz. at Cotham and Kilvington, between Newark and Bottesford; at Barnstone, between Bingham and Stahern; the boring for coal at Owthorpe, near Colston Bassett; and the section at Stanton-on-the-Wolds, between Nottingham and Melton Mowbray. A list of the Rhætic fossils of Notts was given, and the presence of bone-beds noticed. The author could not agree with certain geologists that the green marls which are found beneath the Paper Shales in Notts (nor probably also the "Tea-green Marls" of the West of England) belong to the Rhætic series, but took them to be Upper Keuper Marls, once red in colour, which had become discoloured by some deoxidizing agent, probably carbonic acid evolved during the decomposition of the organic matters of the fossils of the Paper Shales. For, in lithological character the green marls agreed with underlying beds in the Keuper, but differed markedly from the overlying Rhætics; then there was every appearance of a passage between the green marls and the underlying red and green marls of the Keuper; and, lastly, the green marls, like the rest of the Keuper marls, were practically unfossiliferous, while with the commencement of the Paper Shales we get the remains of an abundant, and distinctly marine fauna, in part Liassic.

IV.—Remarks upon the Structure and Classification of the Blastoidea. By P. Herbert Carpenter, M.A.

THE author and Mr. R. Etheridge, jun., who are preparing a joint memoir upon the Blastoidea, have arrived at the following conclusions respecting the group.

It is very doubtful whether the genus *Pentremites* occurs at all in Britain. Some badly-preserved fragments from the Devonian and the Scotch Carboniferous are possibly referable to it; but most of the Blastoids (besides *Codaster*) which occur in the Carboniferous Limestone belong to the genus *Granatocrinus*, Troost., which is represented by some seven or eight species.

Cumberland's *Mitra elliptica* is the representative of a new genus, distinguished by the eccentric position of the spiracles. *Codaster* is a true Blastoid, and not a Cystid, as supposed by Billings. The slit-like openings of its hydrospires are nearly on the same level as the ambulacra, which do not conceal them at all. In the ordinary Blastoids, however, they are below and concealed by the ambulacra, opening externally by pores at the sides of the latter. There are various intermediate forms between these two extremes, in which the hydrospiral slits are more or less concealed by the ambulacra, but are partially visible at their sides. It is proposed to group the species thus distinguished into a genus *Pentremitidea*, which is represented in Britain by the little *Pentremites acutus*, Sowerby, in Belgium by *P. caryophyllatus*, and in Spain by *P. Pailleti*, De Verneuil, for which last the name *Pentremitidea* had been already proposed by D'Orbigny. An arrangement of this kind has been already suggested by Billings.

The discoveries of Rofe, Wachsmuth, and Hambach, respecting the perforation of the lancet-piece by a longitudinal canal, are confirmed. This canal probably lodged the water-vessel, which must have been devoid of any tentacular extensions, as in some Holothurians, and in the arms of certain *Comatulæ*. Respiration was effected, however, by means of the hydrospires. The pores usually found at the sides of the ambulacra were not the sockets for the attachment of the appendages, but led downwards into the hydrospires, serving to introduce water, which made its way out through the spiracles. The genital ducts probably opened into some portion of the hydrospires, as they do into the closely similar structures of the *Ophiuroidea*, and the ova were discharged through the spiracles. Billings' statements are confirmed respecting the existence in many species of a single or possibly double row of joined appendages along each side of the ambulacra; but these appendages are not homologous with the pinnules of the *Crinoidea*.

In perfect specimens the peristome is covered in by a vault of small polygonal plates, any definite arrangement of which is rarely traceable. Extensions of this vault were continued down the sides of the ambulacral grooves, which could thus be closed in completely and converted into tunnels, as in recent Crinoids.

The classification of the Blastoidea must depend entirely upon morphological principles. Mere differences in the relative sizes of the calyx plates are of very little systematic value; and differences in the numbers of side plates on given lengths of the ambulacra are absolutely worthless. On the other hand, the structure and relative positions of the hydrospires and spiracles are morphological characters of much systematic value.

V.—ON THE CHARACTERS OF THE "LANSDOWNE ENCRINITE" (MILLERICRINUS PRATII, Gray, sp.) By P. HERBERT CARPENTER, M.A.

THE "Lansdowne Encrinite" is a species of *Millericrinus* (*M. Pratii*, Gray, sp. = *Apiocrinus obconicus*, Goldfuss) from the Great Oolite on the top of Lansdowne, near Bath. It is remarkable for the very great variation in the characters of its stem and calyx. The former may reach 50 mm. in length, and consist of 70 discoidal joints; or there may be less than ten joints, the lowest of which is rounded off below, and its central canal closed up. Various intermediate conditions may occur between these two extremes, while in some specimens there may be only two to four stem-joints; and in one case the whole stem is represented by a slightly convex imperforate plate on which the basals rest. This specimen, taken by itself, would be naturally regarded as a *Comatula* of advanced age, in which the cirrhus-sockets had disappeared from the centre dorsal just as they do in the recent *Actinometra Jukesii.* The general appearance of the calyx is very similar to that of *Pentacrinus Wyville-Thomsoni* from the North Atlantic. But it is remarkable for the number of small intercalated pieces which it may contain. The basals are frequently separated from one another, or from the radials, by minute plates which, while regularly developed all round the calyx in some specimens, are entirely absent in others.

The nearest allies of *M. Pratii* seem to be *M. Munsterianus*, var. *Buchianus*, and *M. Nodotianus.* It stands on the extreme limit of the genus, connecting it with *Pentacrinus* on the one hand, and with the free *Comatulidæ* on the other. It is thus a synthetic type, as would naturally be expected from its geological position; for it is probably the earliest known species of the genus, except perhaps for two doubtful Liassic forms, which are known only by isolated plates and stem-joints.

VI.—ON THE EXTENSION INTO ESSEX, MIDDLESEX, AND OTHER INLAND COUNTIES, OF THE MUNDESLEY AND WESTLETON BEDS, IN RELATION TO THE AGE OF CERTAIN HILL-GRAVELS AND OF SOME OF THE VALLEYS OF THE SOUTH OF ENGLAND. By J. PRESTWICH, M.A., F.R.S., Professor of Geology in the University of Oxford.

THE author gives in this paper the result of observations commenced more than thirty years since, but delayed publication in consequence of doubts caused by the complexity of the phenomena. As mentioned in the preceding paper, a peculiar group of land, freshwater, and marine beds occupy, on the Norfolk coast, a zone between the Chillesford Clay and the Lower Boulder-clay. As we proceed southward, the land and freshwater conditions are gradually eliminated, and marine conditions then alone prevail. Poorly marked as the marine evidence is in Suffolk, this evidence is entirely wanting further inland, and we have only levels, superposition, and structure to rely on in correlating the fragmentary outliers into which these beds finally resolve themselves. Again on the coast of he Eastern Counties, this group forms a nearly level plane but little above the sea-level, resting everywhere on an undisturbed or very slightly eroded bed of Chillesford Clay, and being succeeded, with but slight evidence of denudation, by the Lower Boulder-clay, or by the Glacial sands and gravel; whereas, as it trends inland, it attains a considerable elevation above the sea-level, passes unconformably over the older Tertiary strata, and has been subjected to a great amount of denudation. On the other hand, the old land which seems to have extended from the eastward as far as the Norfolk coast, is now in great part below the level of the German Ocean. Further, whereas the succeeding Glacial beds all show a drift from northward to southward, this is the only case that has come under the author's notice of a marine drift from southward to the northward.

The Westleton Beds, in their more typical aspect, consist of quartzose sands full of flint pebbles, almost as much worn and as numerous as in the Lower Tertiary sands of Addington. With these are mixed—(1) A good many small white and rose-coloured quartz-pebbles; (2) Pebbles of Lydian stone; (3) Large flattened pebbles of a light-coloured quartzite; and (4) Rolled and worn fragments of Lower Greensand chert. It is the presence of these, and especially of the last, that constitutes so marked a feature of these beds, and which, with the absence of pebbles and rock-fragments of northern origin, serve to separate them from the Inter-glacial sands and shingle with which in places they come into juxtaposition.

The author then proceeds to trace the beds through Essex, and gives a series of railway sections showing these beds, exhibiting usually the appearance of a white gravel, with intercalated ochreous beds, and reposing on a very eroded surface of the London Clay. Near Clare there is a pit in which they exhibit oblique lamination, and might, apart from the want of fossils, be mistaken for a Crag section. Near Braintree, a remarkable section was exposed in the branch railway to that town. It showed these beds much faulted, overlaid irregularly by a darker bed full of New Red Sandstone quartzite pebbles, and the whole covered by indenting Boulder-clay.

In traversing the beds farther westward they undergo further modification. Certain characters remain, however, persistent, and on these we have to rely. 1st, the shingle is composed essentially of chalk-flint pebbles, becoming less worn as we approach the southern limits of the deposit; 2ndly, it often becomes much mixed with flint-pebbles and subangular fragments of compact sandstone derived from the underlying Tertiary strata; 3rdly, the chert and ragstone fragments often so increase in numbers as to constitute a large portion of the gravel. They are worn and subangular, and the chert is identical with the chert of the Lower Greensand of Kent and Surrey; 4thly, the pebbles of white and rose-coloured quartz, of Lydian stone, and of white quartzite become rarer, and in places are wanting. The Lydian stone and some of the small quartz pebbles may be derived, with the chert, from the Lower Greensand, but this will not account for the great number of quartz pebbles found in the Eastern Counties. The quartzite pebbles are equally large but lighter-coloured and more ovoid than those of the New Red. They probably have drifted from a continental area on the east, the author having found similar beds in parts of Belgium. 5thly, the absence of northern drift.

Besides their position under the Boulder-clay on the lines of railway, the Westleton Shingle caps some isolated hills in Essex, such as Danebury and Langdon Hills. It is to this age also that the author would refer the drift gravel capping some of the higher ground in Epping Forest, and also the Middlesex hills around Barnet and Southgate, and extending thence in outliers to the range of hills between Hertford and Hatfield, South Mimms and St. Albans, and possibly as far north as Tyler's Hill, near Chesham. Ranging further westward, it forms a small capping on Horsington Hill, near Harrow, which serves to connect it with its highest position on Bowsey Hill, near Henley-on-Thames. Southward, it caps St. George's Hill, near Weybridge. Approaching its southern boundary, this drift becomes less worn and passes into a subangular flint-gravel, capping several of the hills south of the Thames. At Cherry Down, near Windsor, it consists in large part of subangular fragments of chert and ragstone. It caps Hungary Hill, near Farnham; another hill west of Cæsar's Camp, near Bagshot; Meadow Down, near Guildford; and Pobly Hill, near Dorking. To this period may probably be also assigned the gravel on the top of Well Hill, near Chelsfield, Kent; and some of the sands and gravel on the top of the cliffs near Minster, in the Isle of Sheppey.

The author reserves for another occasion the description of the beds next in order; but he would mention here, that the Boulder-clay and some Glacial gravels occupy in Herts and Berks a lower horizon than the Westleton Beds. It would therefore appear that, while the eastern area was submerged, and the strata followed in regular succession upon a surface which did not undergo denudation, the southern and western area was slowly elevated, and underwent partial denudation before the Upper Boulder-clay was deposited. Previous to the period of the Westleton and Mundesley beds, it is probable that the denudation of the Weald had hardly commenced. The area was spread over by Cretaceous strata under water at the beginning of the Crag period (the Lenham Beds), and judging from the character of the beds which fringe the North Wealden area at Chelsfield, Cherry Down, etc., the author concludes that there was land south of this fringing shingle, whence the great mass of Chalk-flints and of Lower Greensand cherts and ragstone must have been derived. This mass of *débris* serves to attest to the great extent of these strata that have been removed from the Wealden area while yet it was an elevated and not a depressed area. After the rise of the area over which the Westleton Beds extended, it underwent extensive denudation, and it was at this period that the great plain of the Thames Valley received its first outlines, although it was not until much later that the river valley received its last impress.

VII.—ON THE FORMATION OF COAL. By EDWARD WETHERED, F.C.S., F.G.S.

THE author first reviewed the researches of Hutton, Goeppert, MacCulloch, Sir James Hall, Sir W. Logan, and Dr. Dawson, and then summed up the conclusions now entertained as to the formation of Coal, as follows:—

1st. That the beds of fire-clay which underlie all seams of coal represent the original land-surfaces upon which the coal-forming vegetation grew. 2nd. That the *Stigmaria* found in the underclays were the roots of that vegetation, which implies that the plants were of the Lepidodendroid order. 3rd. That the vegetation grew near the mouths of great rivers, in swampy ground, and there underwent submergence; changes then took place which converted the vegetable matter into coal. 4th. That the change of coal from one variety to another, even in the same seam, is the result of metamorphism, and is indirectly caused by the contortion of the surrounding strata, whereby facilities for the escape of gases evolved by the vegetable decomposition have been produced.

The author's exceptions to the above were—1st. That coal was not formed from trees of the Lepidodendroid type, and that therefore the *Stigmaria* found in the underclays are not the roots of the vegetation which gave rise to the coal, unless it was from the spores of such plants, which the author considered wanting in proof, though some coal did undoubtedly contain spores of some kind. 2nd. That the varieties of coal, and the change which sometimes takes place in one and the same seam, are not due to metamorphism, nor are they dependent upon the contorted state of the surrounding strata, but arise from the greater or less chemical decomposition of the vegetable mass, influenced by the circumstances under which it was submerged.

The reasons which had led up to these conclusions were:—1st. That we have proof of other vegetation during the coal-period besides the *Lepidodendra,* but their roots have not been preserved, owing to their being of a more perishable nature than the *Stigmaria.* 2nd. Beds of underclay are frequently met with, full of *Stigmaria,* but are not followed by seams of coal. 3rd. Coal must have been formed from a compact mass of vegetation, such as could not have been produced by large trees (as the *Lepidodendra* were) growing *in situ.* The uniform thickness and comparative freedom from inorganic contamination would demand a mass of vegetation into which only a limited amount of sediment could penetrate. 4th. The finding of a fossil tree standing *in situ,* upon which so much stress had been laid by some authors, is a rarity. Though the author had spent much time underground in collieries, and seen hundreds of fossil trees drifted into the position in which they have been found, he had only twice seen instances of them standing where they have grown. 5th. If seams of coal were formed from Lepidodendroid trees, the tough bas-layer would be easily detected, which has never been the case in any true bed of coal. 6th. If the *Stigmaria* found in the underclays represent the roots of the coal-forming vegetation, we should expect to find the fructifications immediately over the coal, which is not the case; with the exception of *Cordaites*, remains of fossil plants are not found for the first two feet or so over the coal.

After a careful investigation underground of the conditions under which coal was formed, the author has arrived at the following conclusions:—On the land grew the vegetation of the period, represented by *Lepidodendra*, *Sigillaria*, *Calamites*, etc. As the land sank and the waters encroached, the land vegetation gradually disappeared, but the roots remained in many cases, and those which offered the greatest resistance to decay are the ones preserved in a fossil state—hence the occurrence of *Stigmaria*. As the waters advanced, the ground would become swampy, and then we might expect to see spring up reeds, mosses, and other vegetation suitable to the changed condition; it is to vegetation of this kind that the author ascribes the formation of coal.

Reference was then made to the Presidential Address of Professor Ramsay to the British Association in 1880, in which the recurrence of the same kind of incident through geological time was advocated. The author then asked, why the coal formations of the Carboniferous period should be an exception, seeing that the modern lignites and deposits of peat were instances of coal in the process of formation. It was then pointed out that these deposits were not composed of large trees, but of a lower order of growth.

Coming to the varieties of coal, and the change which sometimes takes place in this respect in one and the same seam, it was shown that the difference between bituminous and anthracite coal was, that the latter contained a greater proportion of carbon and a less amount of volatile matter than the former. It was then contended that if the decomposition of the coal-forming vegetation took place without being affected, to any extent, by minerals capable of oxidizing the carbon, that a coal would be formed having a large proportion of carbon with a less proportion of volatile matter than is found in bituminous coals. The author explained this by briefly reviewing the process by which vegetable matter has been converted into coal. It chiefly depended upon the amount of oxygen which could unite with the carbon for carbonic acid, and the amount of hydrogen which could unite with the carbon to form marsh gas. By this process oxygen and hydrogen would pass off in greater proportion than the carbon, thus increasing the proportion of the latter to the whole. If, however, the submerging waters placed in contact with the vegetable mass substances capable of supplying oxygen to the carbon, then there would be a decrease in the proportion of the latter, and what the author termed the 'fixed oxygen and hydrogen' would increase in proportion to the whole and give rise to a coal of a bituminous nature.

With a view of ascertaining whether the chemical composition of the beds overlying a seam of coal which has changed from bituminous to anthracite also changed, the Welsh 'nine feet' seam was selected, which near Cardiff is semi-bituminous and at Aberdare becomes anthracitic. Specimens of the overlying strata were selected from the two districts at each foot above the coal for five feet; these were analyzed, and it was found that the beds from near Cardiff were considerably more argillaceous and, as a whole, less ferruginous, than those at Aberdare. It would be rash to attempt to determine the exact chemical nature of the sediment deposited over the coal-forming vegetation in the two localities, as, with the exception of silicate of alumina, the silicates and other minerals would have undergone decomposition at the expense of the carbonic acid given off from the coal-forming vegetation. There was, however, a decided change in the beds of the two sections presented, which could not be ascribed to metamorphism. It rather appeared to point to the sediment containing different constituents, which must have had a very considerable effect on the vegetable mass. It was to this that the author was inclined to assign the change in the character of the coal.

VIII.—SECOND REPORT OF THE COMMITTEE, CONSISTING OF PROF. P. M. DUNCAN AND MR. G. R. VINE, APPOINTED FOR THE PURPOSE OF REPORTING ON FOSSIL POLYZOA. Drawn up by Mr. VINE (Secretary).

AFTER many laborious researches, naturalists, generally, have accepted Dr. Allman's *Gymnolæmata*, for one at least of the orders of the Class Polyzoa. In this order the "Polypide is destitute of an epistome (foot): and the lophophore is circular."[1] The order is divided into three sub-orders:—

I. *Cheilostomata*, Busk. = *Celleporina*, Ehrenberg.
II. *Cyclostomata*, ,, = *Tubuliporina*, Milne-Ed., Hagenow, Johnston.
III. *Ctenostomata*, ,,

The whole were "founded by Professor Busk on certain structural peculiarities of the cell."[2] Only species belonging to two of these sub-orders are found fossil, and to these alone I shall direct the attention of the reader.

I. CHEILOSTOMATA.—Polyzoa belonging to this sub-order are "distinguished by the presence of a *moveable opercular valve.*"[3] This, however, is not a character on which the Palæontologist can rely for evidence; but there are others. The ova are usually matured in external "marsupiæ," or ova cells; there are also appendicular organs—*avicularia* and *vibricula;* and later investigations have proved the existence of peculiar perforations in the cell-walls, which Reichert called "Rosettenplatten," and Hincks "communication-pores." Through these openings the "endosarcal" cord of Joilet,[4] in the living Polyzoa, passed from cell to cell. The aperture, or mouth of the cell, though variously shaped, is always sub-terminal. To prove that Polyzoa (judging from the calcareous remains of this sub-order) were present in the Palæozoic seas, it is necessary that some one or other of the above-named characters should be present in the species introduced as Cheilostomatous.

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[1] Hincks's Brit. Marine Polyzoa, p. cxxxvi.

[2] *Ibid.* p. cxxiv.

[3] "Corneous," Waters on the use of the Opercula. Proceedings of Manchester Lit. and Phil. Soc., 1878. (Italics mine.)

[4] Nervous tissue, Müller.

II. Cyclostomata.—The simplicity of structure in this sub-order precludes elaborate description. There are, however, a few points of special structure to which it may be as well to direct attention. The cells are invariably tubular, or nearly so; the mouths are circular, and, generally speaking, of the same diameter as the cell. The cell-mouths in many of the Cyclostomata are covered by calcareous opercula, in both recent and fossil species, and these are considered to be—by Mr. F. D. Longe[1]—of an analogous character with the *corneous* opercula of the Cheilostomata. Be this as it may—all the Cyclostomatous opercula are calcareous—and their use has not yet been definitely made out.

In his classification of the British Marine Polyzoa, Mr. Hincks bases his genera and species, to a large extent, upon the shape and character of the cell and cell-mouth,—the habit of species is only of secondary importance. To working naturalists amongst living species his carefully worked-out divisions are of supreme importance, and the Palæontologist may do well to carry over the leading idea of Smitt and Hincks when working out fossil species, especially so when dealing with Palæozoic types. It may be well, too, to caution the student in his use of the generic names of the earlier authors. These have to be revised according to modern usage. In every case where I could retain the original designation of the author of genera and species I have done so, but it seems to me to be a folly to perpetuate a nomenclature which does not indicate generic affinity. In his otherwise carefully written "Introduction," Mr. Hincks says, "There is evidence, however (as I learn on the excellent authority of Mr. R. Etheridge, jun.), of the existence of a few Cheilostomatous genera at least within this epoch (Palæozoic), and probably the group is represented in the Silurian division of it"[2]—a conclusion which, after the most careful research, I am unable to agree with.

In this, as in my former Report, I shall revise the whole of the genera and species that have been introduced since the time of Goldfuss into the nomenclature of Silurian and Devonian literature. I would prefer to deal only with British species, but as many papers describing new genera and species, from foreign sources, have been published in this country, I cannot do otherwise than review, if not revise, these as well. But whereas, in my former Report, I dealt generally with material in my own cabinet, in this I shall refer largely to the Polyzoa in the magnificent collection of the Museum of Practical Geology. For this purpose I have handled, and noted down particulars of every specimen in the collection, from the Lower Silurian to the Devonian. This I have been enabled to do through the kindness of Mr. Etheridge, F.R.S., Palæontologist, and Mr. E. T. Newton, Assistant Naturalist of H. M. Geological Survey, Museum, Jermyn Street.

Professor Duncan has expressed a wish that in this Report I should draw up a suggestive Terminology, that would be in keeping

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[1] Oolitic Polyzoa, F. D. Longe, F.G.S., Geol. Mag., January, 1881. See also Hincks's Brit. Marine Polyzoa, Introduction, p. cv, and pp. 460–1.

[2] Brit. Mar. Poly. p. cxviii. Adding in a note, "Of recent genera *Stomatopora* and *Diastopora* appear to occur in the Silurian Rocks."

with modern usage and applicable to Palæozoic species. In accordance with the spirit of this request the following terms may be accepted generally. In it I have followed the leading of Busk and Hincks, without wholly despising the terms used by our leading Palæontologists.

ZOARIUM.—"The composite structure formed by repeated gemmation," = Polyzoarium and Polypidom of authors.

ZOŒCIUM or cell. "The chamber in which the Polypide is lodged."

CŒNŒCIUM. "The common dermal system of a colony." Applicable alike to the "Frond," or "Polyzoary," of Fenestella, Polypora, Phyllopora, or Synocladia: or to the associated Zoœcia and their connecting "interstitial tubuli," of Ceriopora, Hyphasmapora, and Archæopora, or species allied to these.

FENESTRULES. The square, oblong, or partially rounded openings in the zoarium, —*connected by non-cellular dissepiments*,—of Fenestella, Polypora, and species allied to these.

FENESTRÆ applied to similar openings, whenever connected by the general substance of the zoarium—as in Phyllopora, Clathropora, and the Permian Synocladia.

BRANCHES. The CELL-bearing portions of the zoarium of Glauconome, Fenestella, Polypora, or Synocladia; or the off-shoots from the main-stem of any species.

GONŒCIUM. "A modified zoœcium or cell, set apart for the purposes of reproduction."

GONOCYST. "An inflation of the surface of the zoarium in which the embryos are developed." Modern terms from the Rev. Thos. Hincks, F.R.S.

I have no desire to discuss my use of the term 'Polyzoa' instead of 'Bryozoa.' I use it as a matter of choice after carefully considering all that has been said by my friend Mr. Waters, Hincks, Busk, and others. After all, the question of priority is still an open one, and those of my readers who desire to consult authorities will find ample material in a paper 'On the Priority of the term Polyzoa for the Ascidian Polypes,' Busk, Ann. Nat. Hist., 1852; Rev. T. Hincks' 'Brit. Marine Polyzoa,' p. cxxxii; and A. W. Waters, Ann. Nat. Hist., January, 1880.

Sub-order CHEILOSTOMATA, Busk.

Genus *Hippothoa*, Lamx.

Hippothoa inflata, Nicholson, Ann. Mag. Nat. Hist., February, 1871, pl. xi. fig. 4.

Alecto inflata, Hall, Pal. New York, vol. i. p. 77, pl. xxvi. figs. 7*a*-7*b*.

This species of Hall's has been reworked from fresh material, by Nicholson. The slight figures given by him show a habit nearly akin to *Hippothoa abstersa*, S.W., fig. 6, pl. 22, Busk's 'Crag Polyzoa,' only rather more swollen at the distal part of the cell. In the cell-mouth of Busk's figure the peristome is sinuated: in Nicholson's figure it is circular. There is also a resemblance to Goldfuss' *Aulopora dichotoma*, tab. 65, fig. 2. I know of no species of *Hippothoa*, recent or fossil, with which it can be otherwise favourably compared. Generically it has no affinity with the HIPPOTHOIDÆ of Busk, and without doing violence to the generic character of *Hippothoa* as given by Hincks,[1] it cannot be placed with the genus. The species, Nicholson says, is abundant in the Cincinnati Group of the Hudson River formation, near Cincinnati, Ohio.

Genus *Retepora*, Imperato.

Ever since this genus was introduced in 1559, it has been used

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[1] Brit. Mar. Poly. p. 286.

by authors indiscriminately for all manner of fenestrated Polyzoa. Lamarck, in 1815, fixed the type of Linnæus, *Millepora cellulosa*, calling it *R. cellulosa*, and since then, the name *Retepora* has been used for a genus of the ESCHARIDÆ. None of the so-called Retepora of the Palæozoic era have any affinity with this family, or even with the genus as now understood. The word should be entirely abandoned for every species of Palæozoic Polyzoa.

1836. *Escharina*, Milne-Edwards.
1847. *Escharopora*, Hall.

As both these genera have been used by authors[1] for Palæozoic species, it may be as well to draw attention to its misuse. The types *E. recta* and the var. *nodosa* Hall compares with *Eschara ? scalpellum*—now *Ptilodictya scalpellum*, Lonsd., and the *Escharina* of Milne-Edwards, in part, is the *Microporella* of Hincks, a genus which includes species selected from no fewer than ten genera of recent and fossil Polyzoa.

Laying aside the genus *Ptilodictya*, I have no knowledge of any other Palæozoic Polyzoa that can be, even provisionally, placed with the Cheilostomata. After careful consideration I am reluctantly obliged to say that at present there is no evidence that the sub-order existed in any of the Palæozoic seas, and further, the evidence is very doubtful until we reach the Mesozoic era. Notwithstanding this decision, I shall be amongst the first to acknowledge the earlier existence of types if well-defined evidence is brought to bear in the diagnosis of new discoveries.

Taking into consideration the shape and character of the cell as presenting, apparently, an Escharide type, I think I cannot do better than begin this Report with a revision of the whole of the *Ptilodictya*. M'Coy[2] places this genus as the fourth in his family *Escharidæ*; *Berenicea* being the third genus in the family. From the characters given, "cells shallow, oblong, or ovate, often provided with an operculum, capable of being closed *by special muscles*," M'Coy evidently believed that the Palæozoic species could be naturally placed in this family. The true ESCHARIDÆ are of later date, probably not older than the Lower Oolite, and then not as a typical, but only as a kind of passage group. Leaving the classification as an open question at present, I shall take Lonsdale's definition for the group as redescribed by M'Coy :—

1839. *Ptilodictya*, Lonsdale.
1847. *Stictopora*, Hall.

"Zoarium[3] thin, calcareous, foliaceous, or branching dichotomously; branches sometimes coalescing: a thin, laminar, flattened, concentrically wrinkled central axis; set with oblique, short, subtubular, or ovate cells on both sides, with prominent oval mouths, nearly as large as the cells within; branches often flattened, with the margin solid, sharp-edged, striated, and without cells; the boundary ridges of the cells square or rhomboidal."

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[1] *Escharina angularis*, Lonsd., Morris' Catalogue; *Escharipora recta*, Hall, Pal. N.Y., vol. i. [2] Brit. Palæ. Foss. [3] Corallum, Lonsdale, M'Coy's Pal. Foss.

This genus is very fairly represented by specimens in the Museum Pract. Geol. There are no fewer than ten species named, and three marked "New Sp.," awaiting description. Accepting the work of other authors, I can do no more than furnish notes on them, just as they are named. The first specimen is *P. dichotoma,* Portlock, in the Wyatt-Edgell Coll., and is found in the Lower Llandeilo flags, and the species ranges into the Upper Llandeilo and Caradoc. In the Caradoc, also, we have the *P. acuta,* Hall, which, if correctly identified, is very widely distributed in the American and English Silurians of the same horizon; and *P. explanata,* M'Coy. Three species undescribed, but bearing MS. names by Mr. Etheridge: *P. papillata, P. ramosa, P. scutata.* In the Lower Llandovery we have the *P. fucoides,* M'Coy, a species having a very limited range. In the Upper Llandovery we have *P. lanceolata,* Lonsd., which ranges through the Wenlock Shale, Wenlock Limestone, Lower Ludlow and Aymestry Limestone. There is a departure from the type in *P. scalpellum* (*Eschara* ? *scalpellum,* Lonsd.); it is marked as appearing in the Upper Llandovery and Wenlock Limestone. Hall, in the first vol. of the Pal. New York, figures and describes *P.* (*Stictopora*) *acuta,* which he compares with this species of Lonsdale. In this species, too, there seems to be no central laminar axis. It is found in the Trenton Limestone. With regard to *Ptilodictya lanceolata,* Lonsd., and *Pl. lanceolata,* Goldfuss, there seems to be a little confusion in our varied identifications of species. In the Catalogue of Cambrian and Silurian Fossils,[1] all the *P. lanceolata* found in the Upper Llandovery to the Upper Ludlow series, with the exception of one species found in the Wenlock Limestone, are ascribed to Lonsdale. The Wenlock species is identified as that of *P. lanceolata,* Goldfuss. This confusion is to be regretted, and in justifying the course taken by Mr. E. T. Newton in the Catalogue, I would suggest that the Wenlock shale species receive a new name—*P. Lonsdalii.* There are many characters in this species distinct from the species described by Goldfuss as *Flustra lanceolata.* There is also a pressing necessity that the types of *Ptilodictya* should become fixed, either as a genus or as a family.

Ptilodictya scalpellum is a type somewhat different from that of other species, and under a family name—PTILODICTIDÆ—I should reconsider my own reference to this genus of the Carboniferous *Sulcoretepora.*[2]

Professor Nicholson[3] has added much to our knowledge of this group, by the publication in this country of his papers on American forms. He has also founded two new genera to take in what he considers to be allied types. The Upper Silurian species, which are new, are: 1. *P. falciformis,* Nich., allied to *Escharopora recta,* Hall. His species, however, differs from *Flustra* (*Ptilodictya*) *lanceolata,* Goldf., *P. gladiola* and *P. sulcata,* Billings. 2. *P. emacerata,* Nich., a beautifully delicate species, with "elliptical cells,

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[1] Mus. of Practical Geology, 1878.

[2] Carboniferous Polyzoa, B. A. Rep. 1880, second page of Report.

[3] Ann. Mag. Nat. Hist. March, 1875.

their long axes corresponding with that of the branches, six or seven in the space of one line measured longitudinally." "This Nicholson considers to closely resemble *P. fragilis*, Billings, and it is possible that it may be only a variety of Billings' species."[1] 3. *P. flagellum*, Nich. This also resembles *P. gladiola*, Billings, and it also very closely resembles the *P. Lonsdalii* of our own Wenlock shale, excepting that the "attenuated base" of our own species is rarely "flexuous," but more often truncated and round. 4. *P. fenestelliformis*, Nich. All these species are typical, having the non-poriferous margins and the central laminar axis. One species—*Ptilodictya? arctiopora*, Nich.—has affinities with *P. raripora*, Hall; but Nicholson doubts the possibility of keeping these two species with the genus. The cells closely resemble some of the characters of our own Silurian species, but as there is evidently a departure from the original types, it may be as well to study these passage forms, if such they be, more carefully than they have yet been done. 5. *P. cosciniformis*,[2] Nich.: Hamilton formation, Bosanquet, Ontario.

For species allied to *Ptilodictya*, Nicholson has founded two new genera, and adopted one from Hall.

1874.	*Tæniopora*, Nicholson,	Geol. Mag. 1874.		
,,	*Clathropora*, Hall,	,,	,,	,,
1875.	*Heterodictya*, Nicholson	,,	,,	,,

In *Tæniopora* we have a zoarium that is a flattened, linear, calcareous expansion, with cells on both sides, the branches of which are dichotomous. There is a median ridge on each face of the zoarium, having a longitudinal direction, on the lateral halves of which the cells are developed. These are longitudinally placed in rows of from three to five. The margins are usually plain and non-celluliferous. Two species are described: *T. exigua*, Nich., and *T. penniformis*, Nich., both from the Hamilton group.

In *Clathropora* the zoarium is a kind of membranous flattened expansion, with rounded or oval fenestræ of considerable size. The cells are on both sides, separated by a thin laminar axis. The fenestræ are surrounded by a striped non-celluliferous margin. One species is described—*C. intertexta*, Nich.—from the Corniferous Limestone, but in some respects it resembles *P. cosciniformis*, Nich., of which mention has already been made.

In *Heterodictya* the zoarium forms a simple, flattened, unbranched, two-edged frond, with sub-parallel sides. The cells are in two series; the central cells are perpendicular to the base, the lateral cells are oblique. "In the only species known—*H. gigantea*, Nich. —the cells of a few of the median rows of the frond are straight . . . . and, as I am only acquainted with an exceedingly large species, I should, however, suspect that *Flustra* (*Ptilodictya*) *lanceolata*, Goldf., will very probably turn out to be an example of this genus."[3]

The material for a thorough revision of this genus is not easily accessible. Many of the Bala series are beautiful casts only, and the Upper Silurian species are often bedded in blocks of the Dudley

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[1] *Ibid.* p. 179. [2] Nicholson, Geol. Mag. Jan. 1875. [3] *Ibid.*

Limestone; and I think it very unwise to disturb the present nomenclature without sufficient reason.[1] The MS. names of Mr. Robert Etheridge[2] require confirmation, and the best way to do this would be to describe and figure them. The new genera of Professor Nicholson may in the future embrace some few of the forms already described, but we can hardly supersede the clear definitions of Lonsdale's types as given by M'Coy. In the Lower Ludlow rocks specimens of *P. lanceolata*, Goldf., often break up, showing the concentrically wrinkled central axis. In the Girvan District—Scotland—at least two distinct species of this genus may be found—*P. costellata*, M'Coy, and *P. dichotoma*, Portl.

(*To be concluded in our next Number*)

REVIEWS.

THE GEOLOGICAL BASIS OF THE CHIEF CITIES OF EUROPE. [Der Boden der Hauptstädte Europa's, etc.] By FELIX KARRER. 8vo. pp. 68, with 23 woodcuts. (Holder: Vienna, 1881.)

THIS is a small, but concise and very useful, compendium of the geology of the European cities — Vienna, Paris, London, Brussels, Berlin, St. Petersburgh, and Rome, with their environs, as determined by transverse sections of the great valleys in which they are situated. The water-supply is particularly described; and the artesian borings at the several places are described geologically, and mostly figured as illustrative sections, besides the cross-sections of the respective basins and valleys. These illustrations have been in many cases supplied by the author's geological friends in the said cities, and their aid is carefully acknowledged as well as the other authorities for compiled information. Besides the water supply (by aqueducts and wells), and the health conditions of the cities, the mineral materials of value in arts and manufactures are also noticed. Altogether, this is an excellent work, full of condensed information, and an invaluable manual of the geology of those portions of the important valleys (Danube, Seine, Thames, Senne, Spree, Neva, and Tiber) in which the great cities have been built.—T. R. J.

CORRESPONDENCE.

THE WEALDEN OF HANOVER.

SIR,—In the June Number of the GEOLOGICAL MAGAZINE, pp. 281–283, there is a Review of the Wealden of Hanover (Die Wealdenbildungen der Umgegend von Hannover, von C. Struckmann).

The monograph, we are told, is a detailed description of the Wealden formation from the beds resting upon the Portland Limestone upwards. The Wealden is divided into three stages, each forming a well-marked horizon of life. "The deepest is the "Münder or bunte Wealden-Mergel," representing the Purbeck

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[1] Since writing the above I have been able to study, very carefully, the leading types of Palæozoic *Ptilodictya*. In a future paper on the Family PTILODICTIDÆ I shall be able to correct many inaccuracies of our ordinary nomenclature.

[2] Mus. Pract. Geol. iv. $\frac{4}{40}$ in Catalogue of Camb. and Sil. Fossils.

beds of English geologists, and consisting of thick beds of limestone interstratified with beds of marl, in which are numerous specimens of *Exogyra virgula;* fossils are rare, the most abundant is *Corbula mosensis*, Buv.

Certainly, these "Münder, or bunte Wealden-Mergel" may be regarded, if the above description is correct, as one of the most anomalous formations hitherto discovered. Though a member of the Wealden, they represent the Purbecks, and contain numerous specimens of a fossil characteristic of the Kimmeridge Clay.

But this is nothing to what follows, for we read that "they attain a thickness of 120 mètres, and belong to the Upper Kimmeridge;" so that the aforesaid "Münder or bunte Wealden-Mergel," having started as a Wealden formation, which had swallowed up all the Purbecks, now figure in the Upper Kimmeridge.

But the geological *bouleversement* of this most extraordinary region is not yet at an end, for we read that "over these" "follow dark-coloured beds, twelve mètres in thickness, rich in fossils, as *Exogyra virgula, Pecten concentricus*, etc., etc.," belonging to the Lower Portland, succeeded by the Upper Portland, and Serpulit or Purbeck Limestone.

Now we were told in the first instance that these wonderful Münder-Mergel represented the Purbeck beds of English geologists, and yet in this last passage they are represented as *underlying* not only the Purbeck Limestone but both Upper and Lower Portland. Yet, in the very teeth of this statement, we read in the fifth paragraph of the review, that under the lowest member of the Wealden, viz. the Münder-Mergel, lies the Eimbeckhäuser limestone, "which belongs to the Upper Portlandian, representing a portion of the Upper Jura, and forming, it may be, passage-beds from the Portland to the Wealden." So here we have the wonderful Münder *above* a member of the Upper Portlandian ; in the second paragraph it was *below* the Lower Portland. Unless, therefore, the Lower Portland is above the Upper Portlandian, paragraphs 2 and 5 contradict each other.

This sort of muddle could never have occurred if a proper stratigraphical column had formed part of the work in question. In order to arrive at the real meaning of the author, we append a literal translation of the passage which bears on the subject, followed by a column derived from a subsequent memoir by Herr Struckmann,[1] which will represent what Herr Struckmann intended to show :—

"The Purbeck marls or Münder-marls, which are to be regarded as the transition steps to the Wealden, follow in regular superstratification the Upper Portland Beds, as the equivalent of which near Hanover the Eimbeckhäuser Plattenkalke show themselves. These conditions of stratification are most distinctly observable in the Kappenberg, which stands out from the southern slope of the Deister between Altenhagen and Nienstedt. On the western and south-western slopes of this ridge, between the village of Altenhagen and the point where the road leading over the height from Nienstedt to Messenkamp descends in various windings into the wide valley

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[1] Neues Jahrb. für. Min., etc., 1881, Bd. II. p. 102.

between the Deister and Süntel, there are a series of quarries, which furnish excellent information upon the sequence of the rocks. The strike of the beds runs from S.E. to N.W., with a very slight dip to N.N.E. The lowest beds consist of a very compact, blue limestone divided into thick beds, which is converted into quicklime in many limekilns. Upon this, separated by argillaceous partings, follow compact, oolitic, flaggy limestones with numerous examples of *Exogyra virgula*. Otherwise fossils are scarce; *Corbula mosensis*, Buv., is the one that occurs most abundantly. These beds, which according to Credner attain a thickness of about 120 mètres, belong to the Upper Kimmeridge. Upon them follow a thickness of about 12 mètres of dark, in part black, marly limestones and shaly clays, with occasional intercalated thin, hard, flaggy limestones, rich in fossils, especially *Exogyra virgula*, etc. . . . . . These beds belong to the Lower Portland. Over these come the strata of the Upper Portland or the Eimbeckhäuser Plattenkalke, which cover the whole broad ridge of the Kappenberg, with a thickness, according to H. Credner,[1] of at least 88 mètres. They are on the whole poor in fossils; but *Gervillia obtusa*, etc., are more or less abundant upon particular slabs.

"On the northern slope of the Kappenberg the Plattenkalke are directly overlain by the Purbeck Marls, upon which, for example, the village of Nienstedt stands; they can also be traced along the road to Egestorf as far as the point where the forest road branches off towards the Cöllnische Feld; their thickness here amounts to about 80 mètres; above them follows the Serpulit."

The following is the sequence in the neighbourhood of Hanover, as given by Strückmann in his paper "On the Parallelism of the Hanoverian and English Upper Jurassic Deposits, above referred to:

	England.	Hanover.
Wealden	Weald Clay.	Upper Wealden.
	Hastings beds.	Middle Wealden.
	Purbeck beds.	Purbeck (Serpulite) or Lower Wealden.
Portland		Münder-Mergel as a transition between Purbeck and Portland.
	Portland Stone.	Eimbeckhäuser, Plattenkalke.
	Portland Sand.	Zone of *Ammonites gigas*.
Kimmeridge	Upper Kimmeridge Clay.	Upper Kimmeridge or *Virgula* Beds.
	Lower Kimmeridge Clay.	Middle Kimmeridge or *Pteroceras* Beds.
	Kimmeridge Passage Beds.	L. Kimmeridge (Astartian) = *Nerinæa* beds & Zone of *Terebratula humeralis*.

August, 1881.

J. M. & W. H. H.

A CORRECTION.

Sir,—Will you allow me to correct a mistake I made in a letter appearing in your August Number? Mr. Day's simple method for determining the outcrop on any given surface of a bed or trough of known cylindrical form, by means of a shadow cast in direct sunlight, is equally applicable to the inverse proposition, viz., to determine the form of the trough, knowing the outcrop.

A. F. Griffith, B.A.,
Christ's Coll., Cambridge.

Sandridge Vicarage,
St. Albans, *Aug.* 27, 1881.

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[1] Credner, *Ob. Jura*, p. 68.

REV. H. G. DAY'S REPLY TO MR. A. F. GRIFFITH.

Sir,—A Mr. A. F. Griffith in your August Number comments on my mathematics.

I certainly plead guilty to a single inaccuracy, which did not affect the principle: Mr. Griffith was hardly justified in accusing me of "singular inaccuracy."

I regret that he should fail to recognize that, if a figure A is the shadow of B, B would also be the shadow of A. Also that he should so completely endorse Mr. Fisher's original formulæ, some of which contradict our previous ideas. An example will suffice:—"It appears that no apparent obliquity of trend can be given by a vertical section, *e.g.* by a vertical cliff!" p. 21.

It is superfluous either to criticize work that leads to such an anomaly, or to defend oneself against such an assailant. I leave the public to judge between us. H. G. Day.

CERVUS MEGACEROS IN BERKSHIRE.

Sir,—Further particulars about the antlers mentioned at page 95 of the Geological Magazine for February last having come to hand, I learn that they were found in the Peat at Ufton, near Aldermaston, in the Kennet Valley, when the peat was being dug for Mr. Congreve, the owner of the Aldermaston Estate, about forty years ago. Thomas Benham, living at Tatley, and aged 72, had the specimens direct from Aldermaston House, and the information from the man who found them; and he says that the marl below the peat not being dug into, when they raised the peat there for the purpose of burning it for ashes, the horns came from the peat itself. For notices of the Kennet Peat and its contents, and the manufacture and use of peat-ashes, see the "Transact. of the Newbury District Field-club," vol. ii. 1878, pages 5, 123, 130, 141, 156, etc.

Aug. 31, 1881. T. Rupert Jones.

ROCK-BASINS ON GRANITE TORS IN CORNWALL.

Sir,—I would wish to know your opinion respecting the *origin* of the numerous rock-basins which occur on our granite tors in profusion, and were first noticed by Borlase in his "Antiquities of Cornwall."

They occur also in Wales, I believe, (vide Leland's Itin., vol. v. p. 59), and it would be interesting to know—in opposition to the Druid theory—whether these circular impressions, averaging in Cornwall about two feet in diameter, are concomitants of granite mountain tops the world over.

Borlase assigned them a Druidical origin, believing them to be almost peculiar *to Cornwall*; and that they do not occur on *every* granite eminence I know from actual experience in other lands. For instance, granite peaks of Alleghanies.

Thomas Cragor, F.R.G.S.

Woodbury, Truro, *Sept.* 14, 1881.

THE
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No. XI.—NOVEMBER, 1881.

ORIGINAL ARTICLES.

I.—On Evaporation and Eccentricity, as Co-Factors in Glacial Periods.[1]

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

THE effects of Evaporation on Temperature have often been considered, yet much remains unknown. I am not aware that any one has called attention to the rapidity of its growth as temperature increases, and the consequences that follow.

Dry air coming into contact with water absorbs moisture. It becomes saturated, unable to take up more, when it has absorbed a certain quantity dependent on its temperature. A cubic metre of air at 0C. can hold 4·88 grammes of moisture, at 5C. it can hold 6·81, at 10C. 9·38, at 15C. 12·77, and at 20C. 17·19. Thus the amount of vapour increases much faster than in a simple proportion to the temperature. One well-known consequence of this is that if two currents of saturated air meet at different temperatures, their mixture must be attended by rain. Cubic metres of air at 10C. and 20C. as above together contain 26·57 grammes of moisture. When mixed they take the temperature 15C., but can only hold 25·54 grammes, and the surplus quantity must be precipitated.

Conversely, the capacity for vapour of two cubic metres of dry air at different temperatures is greater than the capacity of two metres at the mean of those temperatures. Now the rate of evaporation from the surface of water is dependent on the capacity for vapour of the air above the water. When other things are equal, the amount of evaporation in a given time will be proportional to this capacity. The amount will therefore depend on the temperature; increasing as the temperature increases, but at a faster rate. Thus the quantity evaporated in an hour of 10C. followed by an hour of 20 C. will exceed that evaporated in two hours of 15 C. The excess as above will be about 4 per cent. So the evaporation during a year at 25 C. will fall short of that resulting from two half years at 20 C. and 30 C. Thus fluctuations in temperature must increase the amount of evaporation. The wider these fluctuations, the greater that increase. The cubic metre of air at temperatures —30 C., 0 C., and 30 C. can hold respectively 0·41, 4·88, 30·85 grammes of moisture. The mean of the first and third is 15·63, which is more than three times the second. Thus the evaporation at a steady freezing tem-

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[1] Communicated to the British Association at the York Meeting of 1881.

perature would not be nearly equal to that produced under a temperature which oscillated from 30 degrees above to 30 degrees below zero. We may express the theorem tersely, though perhaps rather obscurely, as that "*The mean evaporation under varying temperatures exceeds the evaporation at the mean temperature.*" And any cause which increases the fluctuations will still further increase the excess. Thus, "when temperatures vary about a mean, increased variation produces increased evaporation."

Every one who has dipped into the Glacial Epoch controversy will see that this fact has important bearings upon it. All agree that increased eccentricity of the earth's orbit must bring wider variations of temperature. Such wider variations would raise the total evaporation. Increased annual evaporation must produce increased annual precipitation. At present some of the precipitation takes place in rain and some in snow. Each would be augmented. At the Equator there would be heavier rains, at the Poles a greater snowfall and all the consequent effects. A sun nearer than at present in summer, more remote in winter, will give a colder January and hotter July. Hence will follow increased annual evaporation, and increased precipitation, and a Polar snowfall beyond that now experienced. But no increase of total annual heat accompanies this snowfall to melt it. There is reason for a greater fall, but no reason for greater melting. The surplus would accumulate, and although doubtless small, may with sufficient time reach any reasonable amount.

The obvious objection to this argument is one formerly adduced by myself against Dr. Croll, that snow liberates in its formation as much heat as it absorbs in its dissipation. And this objection is valid as regards all snow produced by the meeting of warm and cold air-currents. The cold current is warmed as much as the warm is cooled, and no heat thereby leaves the atmosphere. Increased snowfall if it resulted would be accompanied by increased melting. But there is a way in which heat is lost and snow produced which this objection does not touch. If air be heated, it rises from the ground and carries its heat into higher regions of the atmosphere. Here as the heat is radiated off, it finds a thick blanket of air below, a thinner coverlet above. Much less of the radiated heat will return to earth, much more will be lost in space, than for a like mass of air in contact with the ground. The uprush of warm air will carry with it watery vapour. The particles of vapour under this more rapid radiation will soon cool down, and may reach a very low temperature. When the vapour falls to earth again, it will often fall as snow. Any cause which tends to increase up-currents of air, increases the loss of heat, and increases the rainfall and snowfall. So does any cause which increases the vapour carried aloft by those up-currents. Wider extremes of temperature produce such increase of vapour, and increased eccentricity produces such wider extremes.

A less obvious, very abstruse, but serious difficulty arises from the simultaneous loss of heat by radiation. I have formerly shown (Geol. Mag. 1880, p. 17) that these increased fluctuations of heat-supply, by means of their effect on radiation, lower the average temperature. May not this neutralize the increase of evaporation which would otherwise result?

This difficulty may perhaps be removed by aid of an illustration. The temperature of the earth's surface as heat is being poured on to it depends on the loss of heat from radiation and evaporation, and whatever other causes of loss exist: the temperature rises till the expenditure equals the supply. This is very analogous to the depth of water in a cistern into which there is a continual flow, but from which there is also a continual leakage. If we suppose the leaks to be cracks in the sides, which widen rapidly upwards, we get an analogy to the rapid increase of radiation and evaporation with rising temperature. The water deepens in the cistern till the efflux equals the supply. At that point a large increase of supply may not raise the level much, since the leakage increases so fast as the water rises. But a decrease of supply may lower the level a good deal if the cracks are rather narrow below. If this be the case, an intermittent supply will give a lower average level than a steady supply of the same total amount, which answers to fluctuations in the supply of heat lowering the mean annual temperature.' Again, if one of the cracks widen upwards much more rapidly than the other, it will have a greater share in producing this effect, and the loss through it will be increased. Now as between radiation and evaporation it may be shown that the latter has by far the fastest increase. The latter, therefore, has the principal share in causing the extra loss which follows from varying heat-supply.

It may perhaps be asked, if the heat-loss from evaporation be thus increased while the heat-supply is unchanged, will not the earth be losing more than it receives? Does not this conclusion conflict with the equilibrium of emission and supply? If we export more than we import, must we not be growing poorer in heat? Those who can see this difficulty will probably see the answer, that under such circumstances less is lost by means of radiation: more flows out by one leak, and less by the other.

These reasonings seem to me to prove that increased eccentricity must produce an increased amount of snow. But when we try to calculate the possible amount, we are, as usual, pulled up by an impossibility. This arises in the present case rather from the uncertainty of the data than from any difficulty in the operation. We may, however, form some rough notion of what is possible. Basing a calculation on the assumption of evaporation proportional to capacity of dry air for vapour, we find that a temperature fluctuating 10 F. on each side of 80 F., would give about one-fortieth more precipitation than would a steady 80 F. An equal fluctuation on each side of freezing would give much the same fractional increase. One-fortieth may seem small, but it must not be despised. If the present annual Arctic snowfall were 20 inches, all by supposition just melted, and if an uncompensated increase commence and gradually grow during the 12,000 years which will interchange the seasons and bring the summer of the Northern Hemisphere into perihelion, then even though the utmost snowfall should have reached but 20½ inches, and the unmelted annual increase but half an inch, still the total accumulation would be 250 feet. Even now, snow sometimes lies all the year through on Ben Nevis. Scotland would be very different with such a snow cap on its peaks.

The fluctuation of 10° assumed above has not been taken quite at random. Maximum eccentricity might produce a fluctuation of over 20° were radiation the only means of escape for the heat.[1] This is too great, for the present eccentricity ought by a like calculation to produce a difference of temperature between January and June amounting to about 10° at the Equator. Actually it is, according to K. Johnston, only some 2°. On the other hand (on the same authority), in the Tropics three-fourths of the rainfall occurs in the three hottest months. So it would appear that the additional heat goes almost entirely to augment the precipitation. We can hardly doubt that intenser heat would still further augment the summer precipitation, while that of the remaining months is too small to be very much diminished. For Arctic regions, the few registers I can find (Rink, Nares, Nordenskiold) point either to a similar summer excess, or to a precipitation coming mainly in spring and autumn. A hotter summer would charge the atmosphere with more vapour, which would be precipitated in autumn, probably with more snow.

This action, whatever be its magnitude, works in harmony with Dr. Croll's views. For the greatest extremes of summer heat and winter cold occur with high eccentricity, and with summer during perihelion. The action ought to be most energetic on land surrounded by water. For the summer heat warming the water will produce the intensified evaporation explained, whilst the land will begin to cool faster than the water under winter's cold, and an indraught of moist air may produce increased precipitation. This agrees with the vast extent of the Antarctic ice cap which has always seemed to me too far different from the Arctic ice fields to be due simply to difference of seasons.

In conclusion, I may remark that the immobility of water in the form of snow, expounded by Mr. Wallace in "Island Life," and the increased loss when heat is liberated at a greater elevation, suggested by Dr. Roberts in the GEOLOGICAL MAGAZINE, are both essential points in this theory. The present article supplements them by a third point, that as temperature increases, evaporation increases, but many times as fast, in fact with a transcendental ratio. Were it not for this, alterations of eccentricity would produce only mutually compensating effects. Mr. Wallace, in his admirable discussion, considers the previously suggested actions to be adequate for a glacial period. For my part, here for the first time I see an action seeming certainly able to produce an appreciable effect. And it has yet to pass through its ordeal of criticism.

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[1] These calculations use Dulong and Petit's formula for radiation, and the common assumption that there is a "Temperature of Space" of 150 C below freezing. Neither is at all satisfactory, but the results probably serve fairly for comparisons.

II.—Jurassic Birds and their Allies.[1]

By Professor O. C. Marsh, F.G.S.;
of Yale College, Newhaven, Ct., U.S.A.

ABOUT twenty years ago, two fossil animals of great interest were found in the lithographic slates of Bavaria. One was the skeleton of *Archæopteryx*, now in the British Museum, and the other was the *Compsognathus* preserved in the Royal Museum at Munich. A single feather, to which the name *Archæopteryx* was first applied by Von Meyer, had previously been discovered at the same locality. More recently, another skeleton has been brought to light in the same beds, and is now in the Museum of Berlin. These three specimens of *Archæopteryx* are the only remains of this genus known, while of *Compsognathus* the original skeleton is, up to the present time, the only representative.

When these two animals were first discovered, they were both considered to be reptiles by Wagner, who described *Compsognathus*, and this view has been held by various authors down to the present time. The best authorities, however, now agree with Owen that *Archæopteryx* is a bird, and that *Compsognathus*, as Gegenbaur and Huxley have shown, is a Dinosaurian reptile.

Having been engaged for several years in the investigation of American Mesozoic birds, it became important for me to study the European forms, and I have recently examined with some care the three known specimens of *Archæopteryx*. I have also studied in the Continental Museums various fossil reptiles, including *Compsognathus*, which promised to throw light on the early forms of birds.

During my investigation of *Archæopteryx*, I observed several characters of importance not previously determined, and I have thought it might be appropriate to present them here. The more important of these characters are as follows:—

1. The presence of true teeth, in position, in the skull.
2. Vertebræ biconcave.
3. A well-ossified, broad sternum.
4. Three digits only in the manus, all with claws.
5. Pelvic bones separate.
6. The distal end of fibula in front of tibia.
7. Metatarsals separate, or imperfectly united.

These characters, taken in connexion with the free metacarpals, and long tail, previously described, show clearly that we have in *Archæopteryx* a most remarkable form, which, if a bird, as I believe, is certainly the most reptilian of birds.

If now we examine these various characters in detail, their importance will be apparent. The teeth actually in position in the skull appear to be in the premaxillary, as they are below or in front of the nasal aperture. The form of the teeth, both crown and root, is very similar to the teeth of *Hesperornis*. The fact that some teeth are scattered about near the jaw would suggest that they were implanted in a groove. No teeth are known from the lower jaw, but they were probably present.

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[1] Read before Section D., British Association, at York, Sept. 2nd, 1881.

The presacral vertebræ are all, or nearly all, biconcave, resembling those of *Ichthyornis* in general form, but without the large lateral foramina. There appear to be twenty-one presacral vertebræ, and the same, or nearly the same, number of caudals. The sacral vertebræ are fewer in number than in any known bird, those united together not exceeding five, and probably less.

The scapular arch strongly resembles that of modern birds. The articulation of the scapula and coracoid, and the latter with the sternum, is characteristic; and the furculum is distinctly avian. The sternum is a single broad plate, well ossified. It probably supported a keel, but this is not exposed in the known specimens.

In the wing itself the main interest centres in the manus and its free metacarpals. In form and position these three bones are just what may be seen in some young birds of to-day. This is an important point, as it has been claimed that the hand of *Archæopteryx* is not at all avian, but reptilian. The bones of the reptile are indeed there, but they have already received the stamp of the bird.

One of the most interesting points determined during my investigation of *Archæopteryx* was the separate condition of the pelvic bones. In all other known adult birds, recent and extinct, the three pelvic elements, ilium, ischium, and pubis, are firmly anchylosed. In young birds these bones are separate, and in all known Dinosaurian reptiles they are also distinct. This point may perhaps be made clearer by referring to the two diagrams before you,[1] which I owe to the kindness of my friend Dr. Woodward, of the British Museum, who also gave me excellent facilities for examining the *Archæopteryx* under his care. In the first diagram we have represented the pelvis of an American Jurassic Dinosaur allied to *Iguanodon*, and here the pelvic bones are distinct. The second diagram is an enlarged view of the pelvis of the *Archæopteryx* in the British Museum, and here too the ilium is seen separate from the ischium and pubis.

In birds the fibula is usually incomplete below, but it may be co-ossified with the side of the tibia. In the typical Dinosaurs, *Iguanodon*, for example, the fibula at its distal end stands in front of the tibia, and this is exactly its position in *Archæopteryx*, an interesting point not before seen in birds.

The metatarsal bones of *Archæopteryx* show, on the outer face at least, deep grooves between the three elements, which imply that the latter are distinct, or unite late together. The free metacarpal and separate pelvic bones would also suggest distinct metatarsals, although they were placed closely together, so as to appear connate.

Among other points of interest in *Archæopteryx* may be mentioned the brain-cast, which shows that the brain, although comparatively small, was like that of a bird, and not that of a Dinosaurian reptile. It resembles in form the brain-cast of *Laopteryx*, an American Jurassic bird, which I have recently described. The brain of both these birds appears to have been of a somewhat higher grade than that of *Hesperornis*, but this may have been due to the fact that the latter was an aquatic form, while the Jurassic species were land birds.

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[1] The diagrams referred to were exhibited at the York Meeting, Brit. Association.

As the *Dinosauria* are now generally considered the nearest allies to Birds, it was interesting to find in those investigated many points of resemblance to the latter class. *Compsognathus*, for example, shows in its extremities a striking similarity to *Archæopteryx*. The three-clawed digits of the manus correspond closely with those of that genus; although the bones are of different proportions. The hind feet also have essentially the same structure in both. The vertebræ, however, and the pelvic bones of *Compsognathus* differ materially from those of *Archæopteryx*, and the two forms are in reality widely separated. While examining the *Compsognathus* skeleton, I detected in the abdominal cavity the remains of a small reptile which had not been previously observed. The size and position of this inclosed skeleton would imply that it was a fœtus, but it may possibly have been the young of the same species; or an allied form, that had been swallowed. No similar instance is known among the Dinosaurs.

A point of resemblance of some importance between Birds and Dinosaurs is the clavicle. All birds have these bones, but they have been considered wanting in Dinosaurs. Two specimens of *Iguanodon*, in the British Museum, however, show that these elements of the pectoral arch were present in that genus, and in a diagram before you one of these bones is represented. Some other *Dinosauria* possess clavicles, but in several families of this subclass, as I regard it, they appear to be wanting.

The nearest approach to Birds now known would seem to be in the very small Dinosaurs from the American Jurassic. In some of these the separate bones of the skeleton cannot be distinguished with certainty from those of Jurassic Birds, if the skull is wanting, and even in this part the resemblance is striking. Some of these diminutive Dinosaurs were perhaps arboreal in habit, and the difference between them and the Birds that lived with them may have been at first mainly one of feathers, as I have shown in my Memoir on the *Odontornithes*, published during the past year.

It is an interesting fact that all the Jurassic birds known, both from Europe and America, are land birds, while all from the Cretaceous are aquatic forms. The four oldest known birds, moreover, differ more widely from each other than do any two recent birds. These facts show that we may hope for most important discoveries in the future, especially from the Triassic, which has as yet furnished no authentic trace of birds. For the primitive forms of this class we must evidently look to the Palæozoic rocks.

III.—Note on a Find of *Homalonotus* in Red Beds at Torquay.

By A. Champernowne, M.A., F.G.S.

THIS fine specimen, which has been so faithfully rendered in two views by Miss G. M. Woodward, was found by me, together with portions of other individuals of the genus, in some red finely-sandy or silty beds, interstratified with grits, in the cutting of the new road on the eastern side of Lincombe Hill at Torquay. The beds are traversed by a coarse cleavage dipping south, which usually ignores the hard grit bands. We may call them for the present the "Lincombe, Warberry, and Smuggler's Cove grits," and their probable equivalents will be considered shortly.

Within a hundred yards west of the spot where the specimen occurred, this sub-group becomes mottled with light colours, brown grits appearing, and passes down into the Meadfoot series—properly so-called—but in the opposite direction or north-eastern part of Lincombe Hill, the red beds are seen to be synclined, dipping first N. 25° W. at 25°, and then S. 20° E. at 40°.

The grits of the Meadfoot series are less distinctly quartzose, and are more tenacious, requiring heavier hammers. If we imagine this lower group coloured red, it is difficult to say whether, on purely palæontological grounds, they would be separable from the upper, but it is probable they might be.

The buff and brown weathering of the Meadfoot beds disappears with depth, as the heaps shot out from the Torquay drainage works show, grits and shales alike being of a blue-black tint (coloured with protoxides?); whereas red or purple beds as a rule are so both at the surface and in depth.

In the passage beds described above, I hold that we have a horizon corresponding in general terms with that between the Hangman and Lynton Groups of North Devon. I here refer the reader to a concise paper by Mr. Tawney on this subject.[1] The space at my disposal does not admit of many words, but from some of his conclusions I should somewhat differ. He, however, recognizes that the red beds are newer than the Meadfoot series, against which they are faulted on the coast.

If now we look abroad, we seem to gain some insight into the occurrence of red sandstones of marine origin on the same horizon in the Devonian rocks. In the Eifel District the "Homalonotus Red Flagstones," so named by Murchison, occupy a horizon high in the Lower Devonian beds, scarcely removed from the base of the Calceolen-schiefer, and the bulk of the Coblentzian or Ahrian, the chief home of the *Pleurodictyum problematicum* (though this mud-loving Favositid ranges higher in the series) lies below them. So again I should venture to assume, not yet having seen them, that the red rocks of Burnot (poudingue, schistes rouges de Vicht, etc.) occupy a similar position in the Devonian rocks of Belgium. It is in fact difficult to escape from this conclusion, inasmuch as they overlie the Ahrian, and are themselves overlain by the principal Devonian shales and limestones. M. Mourlon[2] estimates them at from 350 to 400 mètres, about 1230 feet, a thickness fairly comparable with the Hangman beds. He observes that "fossils are very rare in them, as with other Belgian Devonian beds of red colour," but adds that "M. Firket has lately found at Fraipont blocks of fossiliferous 'poudingue,' containing *Stringocephalus Burtini* and *Uncites Gryphus*, characteristic fossils of the limestone of Givet."

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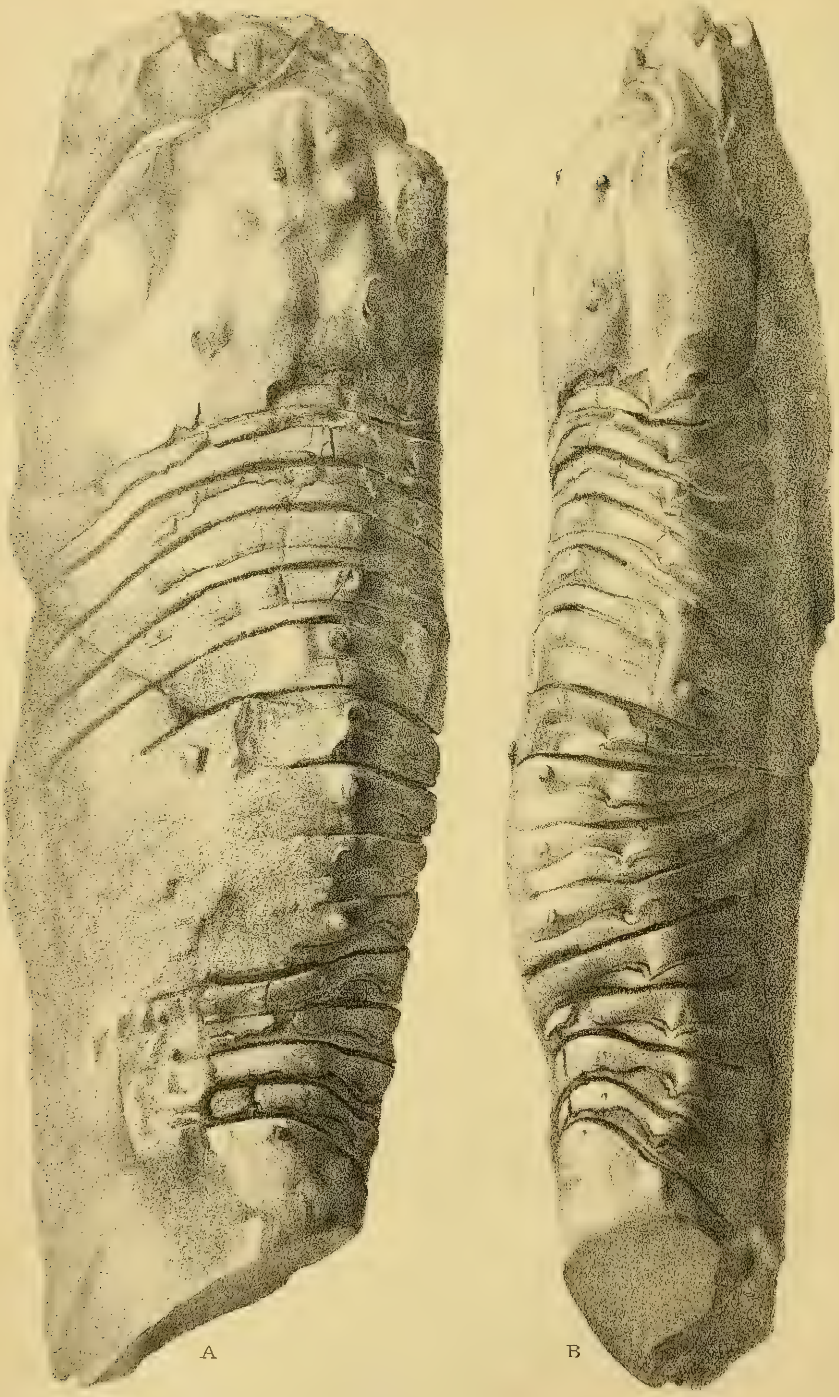
[1] On the Occurrence of Fossils at Smuggler's Cove, Torquay, Report Dev. Association, 1870, p. 291.

[2] Geologie de la Belgique, vol. i. p. 68.



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

Homalonotus Champernownei, H. Woodw.
Devonian; New Cut, Torquay. *(nat. size.)*

This is a circumstance of some interest, when we remember that an upper bed of our Hangman series at West Challacombe Bay contains *Stringocephali* in abundance, as I have seen for myself.

The *Homalonoti* would seem to lie somewhat lower or near the base of the presumed equivalent beds in South Devon, and such appearing to be their geological position, it is a question of classification whether the beds shall be regarded as the uppermost of the Lower or lowest of the Middle Devonian. Mr. Etheridge, as regards the Hangman, adopts the latter view. M. Mourlon classes the beds of Burnot with the Lower Devonian.

Mr. Tawney's Smuggler's Cove list includes "*Homalonotus*, n.sp. (most like *H. Johannis* from the Wenlock beds)." With his list the fossils associated with the *Homalonoti* at the new road would appear to tally, though they are in a bad state of preservation. They include :—

Orthoceras (one specimen).
Holopella (or other *Gasteropod* with the aperture entire :—5-whorled).
Cypricardites ? sp.
Myalina (small).
Tentaculites (not common as quoted by Mr. Tawney from Smuggler's Cove).
Chonetes sordida, Phill., often crowded in certain layers.
(See additions in postscript this month, p. 528.)

At Smuggler's Cove, with Mr. Lee, we found in reddish schistose masses slipped from the cliff many casts of *Orthis*, *Spirifera*, and *Leptœna laticosta*. The bed effervesces, being an impure limestone.

Some Lower Devonian beds are so like some Ludlow Rocks (only red-stained), and with flakes of greenish clay within the gritty layers, as we see in the Usk district with *Holopellæ* and *Chonetes*, as sorely to try the faith of the most orthodox.

We can claim no Foreland beds in South Devon, the Meadfoot beds, equivalent to the Lynton, being to all appearance the lowest visible.

IV.—NOTE ON A NEW ENGLISH *HOMALONOTUS* FROM THE DEVONIAN, TORQUAY, S. DEVON.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE XIII.)

THE fossil, which forms the subject of our Plate, is a most welcome addition to our list of Middle Devonian fossils,[1] and I am much indebted to my friend Mr. Arthur Champernowne, F.G.S., for the opportunity of describing it.

This fine Trilobite is rather larger than the celebrated *Homalonotus delphinocephalus*, Green, from the Wenlock Limestone of Dudley, but although somewhat distorted by slaty cleavage, it can readily be seen that the Torquay fossil is referable to Mr. J. W. Salter's section of *Homalonoti with spines*, which he named *Burmeisteria*. This division includes all those species having the body "elongate, convex; head triangular; eyes approximate on gibbous cheeks. Glabella distinct, lobeless, sinuous. Thorax slightly-lobed and spinous, as is also the many-ribbed pointed tail. (Type *H. Herschelli*) Devonian."

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[1] See *Postscript* to this article with list of additional fossils given on p. 528.

This section of *Homalonoti* is interesting on account of its wide distribution, as may be seen by the following list:—

1.	*Homalonotus*	*Herschelli*, Murch.,	Devonian,	South Africa.
2.	,,	*armatus*, Burm.	,,	Eifel, Rhenish Prussia.
3.	,,	*elongatus*, Salter,	,,	South Devon.
4.	,,	*Pradoanus*, De Vern.	,,	Spain.

The species described by Mr. Salter from the Lower Devonian, Meadfoot Sands, S. Devon, as *Homalonotus elongatus*, is founded upon *a tail only*, remarkable even in this elongated genus for its lengthened shape. A careful study of *H. elongatus*, Salter (given on plate x. figs. 1 and 2, of Mr. Salter's Monograph, Pal. Soc. 1865, part ii., British Trilobites, p. 122), leads me to conclude that Mr. Champernowne's fossil cannot have belonged to this species. For in all the *Homalonoti*, the thoracic somites pass by an almost insensible gradation into the tail-portion, with little or no change in the style of ornamentation between the free and moveable ribs of the thorax and the consolidated caudal series. The unique specimen of *H. elongatus* in Mr. Townshend Hall's Collection is very strongly trilobed, and appears to have had four pairs of spines along its median axis, and two pairs upon the lateral portions. Mr. Champernowne's specimen has little or no signs of trilobation, being in this respect very like in form to the *Homalonotus Herschelli* from the Cape, and *H. delphinocephalus* from Dudley.

Although but a cast, from which all trace of the actual shell has disappeared, the pseudomorph shows that this species had thirteen free and moveable thoracic ribs with broadly expanded pleuræ each armed with a pair of spines placed about one inch apart and forming two parallel rows. The glabella is oblong and has three pairs of spines placed on the lateral portion and three along the median line, of which the most anterior appears to have been double. There is no evidence of any cheek-spines.

The eyes appear to be situated nearer to the genal border than in *H. armatus*, and the rostrum is rather more prominently developed. If we assume the tail-portion when perfect to have been two inches (which is fully within the relative proportions—judging from many other species), this would give the Torquay specimen a length of 8 inches and a breadth measured along the curve of the thorax at its widest part of $3\frac{3}{4}$ inches.

The Eifel species (*H. armatus*) is relatively broader and shorter, measuring 6 inches in length by 3 inches across the widest part of the thorax.

The fossil displays almost better than any other specimen I have seen the beautiful cardinal or hinge-like joints by which the segments of the thorax are articulated with one another; precisely the same in construction as the hinges in the jointed somites of the tail of a living lobster. (See Plate XIII. *B.* side-view.)

After careful comparison with the other species, I am led to conclude, from the position of the eyes, the spines on the head, the proportions of the thoracic somites, and the relative size of the fossil as compared with its two nearest allied forms, *H. armatus* and *H.*

Herschelli, that it is specifically distinct from either of these spinose species of *Homalonoti,* and also from *H. elongatus,* as already stated.

I have, therefore, much pleasure in dedicating this new Devonian *Homalonotus* to the discoverer as *H. Champernownei,* sp. nov., from the Lincombe and Warberry Grits, New Cut, Torquay ; which are probably the equivalent of the Hangman Grits and of the *Homalonotus* red flagstone of the Eifel.

V.—Notice of New Fish Remains from the Blackband Ironstone of Borough Lee, near Edinburgh. No. II.[1]

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

Cryphiolepis, gen. nov.

CRANIAL structure typically palæoniscoid, with wide gape and oblique suspensorium; teeth conical, sharp, incurved, of different sizes, larger alternating with smaller. Fins palæoniscoid, fulcrated ; dorsal nearly opposite the interval between the ventrals and the anal; caudal powerfully heterocercal, deeply cleft, inequilobate. Body-scales thin, rounded, but seldom symmetrically so, deeply imbricating; their external free or ganoid areæ distinctly marked off, and sculptured with closely set ridges which are apparently tubular internally. Scales of the caudal body-prolongation of the usual palæoniscoid contour.

Cryphiolepis striatus, Traq.

Cœlacanthus striatus, Traq. Geol. Mag. Jan. 1881.

A few weeks ago, I was somewhat startled by the discovery that the scales, to which in the Geological Magazine for January of this year, I gave the name of *Cœlacanthus striatus,* belonged, not to a *Cœlacanthus* at all, but to a fish, in other respects, of typically Palæoniscid structure! The error was no doubt a serious one, but also one, which I think any one who looks at the detached scales,—thin, rounded, deeply imbricating, and delicately striated on their free surfaces, as they are,—will readily be disposed to excuse. As it is, our knowledge of the British Palæozoic fauna is enriched by the addition of a remarkably aberrant form of *Palæoniscidæ,* and one which shows not only how dangerous it may be to found conclusions on fragmentary remains, but also how small may be the systematic value of the mere external shapes of the scales of Ganoid Fishes.

The first specimen which opened my eyes to the true nature of the fish in question, was a fragment showing, attached to a mass of the scales of the supposed *Cœlacanthus,* a ventral and anal fin of distinctly Palæoniscid structure, along with a few rays of the caudal. Anteriorly is found a mandible, whose form, sculpture, and dentition at once throws light upon certain detached mandibles, which I had previously obtained, and supposed to belong to a new species of *Elonichthys.* The next specimen was more perfect, and showed the entire figure of the fish, with head and tail, and all the fins, save the pectoral, in a tolerably good state of preservation.

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[1] For Part I. see Geol. Mag. January, 1881, pp. 34–37.

This more perfect specimen measures altogether 5 inches in length by 2¼ in greatest depth at the ventral fins; the shape of the body is thus deep and ovoid, but the appearance of the head and the jumbled condition of the scales leave room for suspicion that its proportions may be somewhat shortened up by post-mortem distortion.

The bones of the head are not in a very good state of preservation, yet they show quite enough to prove in an unmistakeable way their typically palæoniscoid arrangement. The hyomandibular suspensorium is very oblique, the gape proportionably wide. The maxilla is in shape very like that of *Cosmoptychius striatus*, and like it has its broad portion marked with fine closely set ridges, mostly parallel with its upper and posterior margins. The mandible is here badly preserved, though the mouth is seen lying pretty widely open. Detached dentary bones in my collection are about an inch, sometimes a little more, in length; stout, and tapering anteriorly; the depth behind being $\frac{1}{5}$, and near the symphysis $\frac{1}{10}$ of entire length; the outer surface is ornamented with rather fine, closely set ridges, which are parallel with the lower but oblique to the upper margin of the bone; the upper margin itself is set at short intervals with stout, conical, pointed and incurved teeth, between which may be observed others of smaller size, and more externally placed. The opercular bones are ill preserved though evidently arranged in palæoniscid fashion; the clavicle is of the form prevalent in this family, and is externally ornamented with ridges, which are coarser than those of the facial bones.

The ventral fin, of considerable size and consisting of numerous closely set rays, is of the usual acuminate form; the dorsal is very imperfect, but its position is clearly seen to be nearly opposite the interval between the ventrals and the anal; the latter, though the extremities of its anterior rays are broken up, is evidently of the ordinary palæoniscid shape, triangular-acuminate and falling away rapidly behind. The rays of the lower lobe of the caudal are likewise broken up towards their extremities, and those of the upper have their joints altogether dislocated and jumbled, but the typically palæoniscid configuration of the fin is unmistakeable, being strongly heterocercal with well-preserved body-prolongation, deeply cleft and doubtless considerably inequilobate. The rays of all the fins are numerous, closely set, and divided by transverse articulations, which leave the joints rather longer than broad; their outer surfaces are brilliantly ganoid, and ornamented by a few longitudinal grooves, which in the rays of the upper lobe of the caudal are numerous and close enough to form a regular striation.

The caudal body-prolongation is bordered above by a row of acutely pointed, strongly-striated V-scales; those clothing its sides also conform to the ordinary palæoniscid type, being minute, acutely lozenge-shaped, and externally nearly smooth, being ornamented only by one or two longitudinal grooves.

But, on the tail pedicle, and over all the rest of the body the scales are thin and of a rounded shape, though it must also be observed that in few cases are they quite symmetrically rounded, there being usually more or less of a peculiar obliquity of form, which reminds us, to some small extent, of the rhombic contour of the ordinary palæoniscid scale. On their attached surfaces these scales are smooth, and perfectly destitute of the vertical keel, articular spine and socket found in ordinary *Palæoniscidæ* and in most other rhombic scaled Ganoids. The outer surface shows posteriorly a free ganoid and sculptured area, occupying about $\frac{1}{3}$ of the entire space, the remaining covered portion being dull and marked with very delicate concentric lines of growth. The exposed area is covered with fine, brilliantly ganoid ridges, raised above the general surface, closely set, subparallel, and proceeding to the posterior margin without convergence; they are frequently intercalated, but more rarely appear to bifurcate. When examined by a hand lens, these ridges, where the surface is abraded, appear to be hollow internally with only a very thin external covering, their tubular interiors being filled with white carbonate of lime, but I have not yet had the opportunity of subjecting the structure of the scales to examination by the compound microscope.

Remarks.—The occurrence of a palæoniscid fish with rounded imbricating scales, though new to British rocks, is not altogether new to science. Already in 1875 Prof. Anton Fritsch, of Prague, had discovered in the Lower Permian Gas Coal of Kounova, in Bohemia, a small fish he thus briefly noticed,—

"(Nov. gen.) *Kounoviensis.*—Ist eine neue Gattung von Fischen, die bei dem Gesammthabitus eines *Palæoniscus* mit Cycloiden-Schuppen versehen ist. Die Schwanzflosse ist heterocerc, die Kiefern mit grossen spitzen Zähnen versehen. Die Gesammtlänge beträgt 10 cm. Der Höhe nach sind 12 Schuppenreihen der Länge nach etwa 50."[1] For this new and interesting genus Prof. Fritsch afterwards proposed the name *Sphærolepis*,[2] stating that the scales are "kreisrund," but I am not aware of his having as yet published any full generic or specific diagnosis of the fish. Accordingly, with a view of ascertaining the generic relationship of the above described Carboniferous fish to the Bohemian *Sphærolepis*, I have carefully examined a specimen of the latter, which the British Museum obtained some years ago from Prof. Fritsch himself. Naturally, however, I feel great reluctance and delicacy as to entering into any detail as to Prof. Fritsch's fish, before he has himself overtaken its complete description and illustration in his magnificent work on the Vertebrata of the Bohemian Permian Gas Coal and Limestones, now in course of publication. It will be quite sufficient to state that the symmetrical, and consequently more typically "cycloidal" contour of its scales, and the apparent absence of a sharply defined area with peculiar tubular ridges, together with other points, seem to me to be ample justification for erecting the Borough Lee fish into a separate genus. For this I propose the term *Cryphiolepis*, on account of the decep-

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[1] Sitzungsberichte der k. böhm, Gesellsch. der Weiss, 19 March, 1875.

[2] *Ib.* Jan. 1877, also March, 1879.

tive appearance of the scales when found in an isolated, or detached condition.

Geological Position and Locality.—In the Blackband Ironstone of the Middle Carboniferous Limestone Series, worked at Borough Lee, near Edinburgh.

VI.—THE METAMORPHIC AND ASSOCIATED ROCKS SOUTH OF WEXFORD.

By C. CALLAWAY, M.A., D.Sc. Lond., F.G.S.

IRISH land, which has so long puzzled our statesmen, proves to be equally perplexing to our geologists. The metamorphic rocks have excited much controversy, and new problems are emerging. Prof. Hull[1] claims to have found Laurentians in Donegal, Galway, and intermediate localities, while Mr. Kinahan, in this MAGAZINE,[2] sums up the evidence for the old opinions. As I have recently studied one of the areas referred to by the latter, I submit a few comments on a part of his paper. I am much indebted to him for the very kind and courteous manner in which he abridged my work by indicating the most important sections, and regret that I must ungratefully repay the obligation by differing widely from his conclusions.

Mr. Kinahan utters a very just caution against attaching undue importance to lithological characters. Lithology must undoubtedly be subordinate to petrology. But the Archæan geologists are quite justified in accepting, with due precautions, the guidance of lithology, when petrology is not available.

The paragraph (p. 427) in Mr. Kinahan's paper which I venture to criticize runs thus:—"The rocks of the Carnsore or S.E. Wexford district I have very carefully worked out, and to me it appears that northward and westward they gradually merge into unmetamorphic rocks; and in the latter are found *Oldhamia*, a Cambrian fossil." These words call for special comment, because, as it appears to me, they express a fallacy of observation which has led to very erroneous conclusions. The argument mainly runs upon the words "gradually merge." I shall endeavour to show that the facts of the case can only be met by inserting "do not" before "gradually."

It has been frequently assumed that, if a metamorphic rock lies near unaltered beds whose age is determined by fossils, the former must be an altered portion of the latter series. The possibility that the two rocks were brought together by faults has not received due attention. In the Survey Map of Anglesey, as I have shown in this MAGAZINE and elsewhere, the same beds are in one place coloured "Cambrian" and in another "Silurian," simply because they were locally associated with those groups; whereas, on a closer examination, the junctions between the altered and unaltered series were invariably seen to be faults. I contend that the same oversight has vitiated the published work on the geology of Wexford.

The Survey Map of the Carnsore area represents three parallel

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[1] British Association, 1881; and previously in *Nature.*

[2] September, 1881; also British Association, 1881.

bands striking to the west-south-west, and respectively consisting, taking them from south to north, of (1) granite, (2) metamorphic schist, and (3) unaltered Ordovician. This arrangement, if accepted, would seem to lend some support to Mr. Kinahan's opinion of a gradual passage between the granite and the Ordovician, or, according to his more recent view, Cambrian. But the three unbroken strips of colour do not truly represent the facts. It would be more correct to describe the district as a mosaic of irregular fragments. The ground is scored with faults, some of them so close together that, within an acre, at least three formations sometimes crop to the surface. The broken nature of the district is, indeed, recognized by Mr. Kinahan in the "Survey Memoir," and in his "Geology of Ireland;" but he nevertheless maintains that there is a passage between the metamorphic and the unaltered rocks, though no clear case of transition is recorded in his works, and all the facts I observed in the field were inconsistent with such a supposition. But some details must be given.

Carnsore Granite.—There are two points to be considered here. First, is the rock metamorphic or igneous? Mr. Kinahan affirms that it is metamorphic, with igneous intrusions. Of the former point I could find no proof. I searched the coast section from Carnsore Point to the most northerly limit of the granite band, as indicated on the map, and could detect no trace of anything but undoubted igneous granite. I examined the ground for some distance inland, and searched dozens of stone walls, but the result was the same. The rock is perfectly crystalline, and is, indeed, porphyritic, large prisms of felspar being thickly scattered through the matrix. If metamorphic granite occurs in mass, it is singular that in so limited an area it should be so difficult of detection, especially as I searched all the localities in which Mr. Kinahan states that foliation occurs. There is, however, plenty of parallel jointing, which may have been taken for bedding.

Second, does the Carnsore granite pass into the schistose band? Of this no proof is even adduced. No sections are given or localities named. We have nothing but the general statement that the granite graduates through schist and "submetamorphic" rocks into unaltered Cambrian. Very few exposures occur near the line of junction, but I found, about 200 yards north of the line, south-east of Lady's Well, a thin-bedded dark gneiss with garnets, a rock which certainly bore no signs of a character intermediate between porphyritic granite and the schists of the second band. Indeed, this gneiss is far less granitoid than some beds which occur much further from the granite. The granite of the Saltee Islands, which I did not examine, is also said to be metamorphic, but, as it lies several miles south of the second or schistose zone, it is obvious that it is of no use for our purpose.

Metamorphic Band.—This zone is about one mile wide, striking west-south-west to Crossfarnoge Point. The rock is typically a greenish chloritic gneiss, spotted with grains of felspar. It sometimes varies into chlorite schist, and is often interfoliated with felspathic or quartzo-felspathic seams. The chlorite variety is sometimes so fine-grained as to resemble a slate, but, even under the pocket-lens, it is seen to be a true foliated schist.

According to hypothesis, these schists should graduate into the "submetamorphic" rocks, but of this passage there is no satisfactory proof. In the immediate Carnsore district there are no junction sections. The Survey Map, indeed, represents the two groups in contact north-east of Ballytrent House; but, after a careful examination of the section, I could find no trace of the less altered series. The rocks are here very clearly exposed in the shore for about half a mile, the junction being placed on the Map in about the middle of the section. The facts do not justify this separation. The whole series is truly metamorphic, consisting of the types I have described. The green slaty-looking bands, which are frequently intercalated with gneissose beds, have apparently been mistaken for the rocks of the "submetamorphic" group, from which they widely differ in their degree of metamorphism. These green rocks are thoroughly, though minutely, crystalline; whereas the "submetamorphic" group is typically a felspathic slate in which metamorphism does not advance beyond the incipient stage.

Seven miles to the west-south-west, near Tom Haggard, we find the two series in contact, but there are no signs of a passage, and the junction has all the appearances of a fault. North of the junction, we find nothing but pale-green slates, with here and there some gritty bands. I traced the succession for about two miles across the "submetamorphic" zone. Sometimes the rocks bore slight traces of foliation, but the alteration occurred at irregular intervals, and did not increase towards the junction with the metamorphic series. The slates stopped abruptly on the north side of a slight depression, and, immediately to the south of the hollow, we come to gneiss and chlorite schist, with no trace of the slate series.

Both types are well seen on the shore north of Greenore Point with their ordinary lithological characters. Masses of gneiss and of green slate lie side by side, but in no case could I find a passage between the two. In one spot, near the Point, they occur on exactly the same strike, the beds of the slate seeming to be a continuation of the gneiss; but there is no merging of the one into the other, and the junction is clearly a fault. In another place, a mass of red sandstone is let in between two areas of gneiss and slate lying on the same strike.

I was so satisfied in the Carnsore district that the two formations were brought together by faults, that I thought it unnecessary to examine the section at Crossfarnoge Point, especially as Mr. Du Noyer's Map quite bears out my views. At the north end of this Map is an area of "submetamorphic rocks," bounded on the south by a "gabbro dyke." South of the dyke, Mr. Du Noyer represents "gneiss alternating with schist," "granitoid gneiss," and "gneiss, with some schist bands," a description which agrees very well with what I saw on the same strike near Ballytrent House. Mr. Kinahan, indeed, represents the case somewhat differently. Mr. Du Noyer's "schists" he calls "argillites," and he supposes they are the same as the "submetamorphic rocks" north of the dyke; but as he himself describes his "argillites" as "principally talcose and hornblendic," it is obvious that they cannot be identical with the slates of the "submetamorphic" series, which, though sometimes slightly talcose (or chloritic), are never hornblendic.

"LOWER SILURIAN" ZONE.—This band (*b* 2) occupies the country between the metamorphic zone, and the Carboniferous band south of Wexford. From Mr. Kinahan's later works, I understand he has modified his original opinion, and has adopted a Cambrian age for the rocks. I believe it will be found that four distinct formations are represented within the area.

(1) *Ordovician.*—Grey shale, grit, and conglomerate, near Tagoat, with *Orthis Actoniæ* and *O. testudinaria.* Black and grey shales at Bannow. These, the ordinary types of the district, show their affinity with the Bala series, not only in their fossils, but by their close lithological resemblance.

(2) *Cambrian* (*Longmynd*).—The prevailing types are pale-green, red, and purple clay-slates. They are well seen on the shore at Bannow, and are said to contain *Oldhamia.* They are true argillaceous deposits, and are easily distinguishable from the felspathic slates of the "submetamorphic" group. Considering the great distance between the two areas, their resemblance to the Salopian types is very striking. In an examination of the localities where they are said to pass into "submetamorphic" rocks, I failed to find the slightest foundation for such a conclusion. The Cambrian is as unaltered as in the Longmynd Hills, while the felspathic series usually exhibits a slight glaze indicative of incipient metamorphism, and sometimes contains beds of hornstone.

(3) *Hypometamorphic series.*—As these rocks are everywhere faulted against other formations, petrology furnishes us with no proof of their age. They are quite unlike Ordovician and Cambrian, both in mineral characters and state of alteration. At the same time, their resemblance in both points to the Pebidian rocks of Anglesey is very marked. It is difficult to present the full force of this argument on paper, but after several months' close study of the Welsh types, my examination of the Wexford rocks produced a very strong opinion of the identity of the two series. The prevailing rock in both areas is the pale-green altered felspathic slate. Similar grits and hornstones also occur. Bands of quartzite, which are not usual in Pebidian rocks in England and South Wales, are found in Anglesey, and more conspicuously in the Wexford district. Any inference from the strong lithological affinities here indicated could not, of course, withstand clear stratigraphical evidence, but, as such proof is wanting, lithology affords a high probability of contemporaneity.

(4) *Metamorphic series.*—Here also petrology is of little service, and lithology is again almost the only available guide. Comparing these rocks with our known gneissic formations, the Lewisian and the Anglesey group, presumably Dimetian, the resemblance to the

latter is much the closer. The green chlorite schists, which are so marked a feature in Anglesey, are almost equally conspicuous in the Carnsore area; while the gneissose and granitoid types are also similar in both localities. In Anglesey, however, granitoid rock forms a thick band at the summit of the series, while, in Wexford, granitoid seams, usually of no great thickness, are intercalated with the green schists. It is also to be observed that if the strike of the Anglesey schist were produced to the south-west, it would pass through the Carnsore district. The massive, highly crystalline character of the Lewisian gneiss, together with the predominance of hornblendic and micaceous constituents, strongly distinguishes it from the Carnsore schists.

These four types, Ordovician, Cambrian, Pebidian, and (?) Dimetian, are represented in this narrow band. All the groups have a prevailing strike to the west-south-west, but wherever observed, and sections described as critical were selected, there were no indications of a passage between any two of the formations.

I have recognized the Pebidians in other parts of Leinster, but their description lies beyond the scope of the present paper. It may perhaps be hoped that the discovery of this new series in Ireland will clear up some difficulties. The lithology of these rocks has obviously perplexed Irish geologists, and they have been referred to more than one formation. Their distinct mineral characters should, however, enable their distribution to be determined.

I had not intended to publish anything on Irish Archæan geology until I had visited other districts, but Mr. Kinahan's challenge seemed to call for reply, and I have ventured to contribute from my notes such facts as bear upon his views.

VII.—NOTE ON THE GENERIC DISTINCTNESS OF *PURPUROIDEA* AND *PURPURA*, WITH REMARKS UPON THE PURPUROID SHELLS FIGURED IN THE GEOL. MAG. PLATE VIII. DECADE II. VOL. VII. 1880.

By JOHN LYCETT, L.R.C.P.E., and M.R.C.S. Engl.

THE genus *Purpuroidea* was described by me in 1848 from three species in the Great Oolite of Gloucestershire, and published in the Annals and Magazine of Natural History, accompanied by woodcuts representing one of the species. Before that period M. Buvignier had described and figured three species of the same genus from the Coral Rag of France, Mem. Soc. Philomath. Verdun, 1843, accompanied by plates illustrating the species, which he assigned to the genus *Purpura;* these figures were for the most part insufficient for the purposes of generic discrimination, and founded upon specimens more or less imperfect; one of them was believed by me to be identical with the species figured in my woodcut, and was accordingly named by me *Purpuroidea nodulata*, the name of the species having been adopted from the *Murex nodulatus* of Young and Bird, which was also believed to be identical with the Gloucestershire species. At the period in question (1848) only one other Jurassic species attributed to the genus was known, viz. the *Murex tuberosus* of Sowerby's Mineral Conchology, tab. 578, figured in 1827 from the Pisolite of Malton, a specimen so imperfect that it was stated by Mr. Sowerby to be but little better than a cast, and accordingly he did not venture to determine the genus with any certainty. I had, however, a conviction that Sowerby's shell (tab. 578) was identical generically, and perhaps as a species also, with the *Murex nodulatus* of Young and Bird, whose figure in the first edition of their work (1822) was assigned to the genus *Buccinum.* My description of the genus *Purpuroidea,* given in the Annals and Magazine of Natural History in 1848, was perfectly correct in definition, but had one disadvantage, that it did not include a close comparison of *all* the features which separate it from the living and Tertiary *Purpuræ;* at the period in question it was impossible to prove that all the species of *Purpuroidea,* represented by the few and for the most part imperfectly developed fossils then known, were destitute of an important generic feature possessed by *Purpura,* which I will now allude to. The shells of *Purpura,* both living and Tertiary, have a posterior respiratory excurrent or anal canal, forming an internal groove at the posteal junction of the outer lip with the columella; the groove is always well defined, and in none more clearly than in the little *Purpura lapillus* so common upon our coasts. *The shells of the Jurassic Purpuroidea are all destitute of this feature,* which is possessed also by some other recent genera of the *Siphonostomata.*

In 1852 appeared the splendid Atlas of Buvignier illustrating the Jurassic fossils of the Meuse, and containing finely executed figures of the three *Purpuræ* previously figured by him, and fully proving their distinctness from the Great Oolite species of England. Several years subsequently M. E. Piette described and figured three other species of our genus from the Great Oolite of the Ardennes and l'Aisne, Bull. Soc. Géol. France, tom. 13, pl. 12, 13, 14, pp. 290, 296; these also were all assigned to the recent genus *Pupura,* and one of them to the Gloucestershire Great Oolite species *P. glabra.* This I believe to be an erroneous identification. To these must now be added the figures of two species of *Purpuroidea* by Mr. Hudleston, occupying Plate VIII. in this Magazine for 1880. There are therefore now known, described, and figured, six species of *Purpuroidea* in the Great Oolite, three in England and three in France; five species in the Corallian rocks, three in France, and two in England, to which may be added not less than two other species hitherto undescribed, but noticed by Mr. Hudleston, one in the Coral Rag of Yorkshire, and a small one in the Portland formation in the limestone of Portland; the eleven species already described are believed to be all separate forms. In mentioning *three* Great Oolite British species, I purposely omit the *Purpuroidea insignis,* Lyc., figured and described from a single specimen in my supplement to the Great Oolite, Monograph, p. 6, pl. 31, figs. 2, 2*a*, as I am now convinced that the specimen upon which that species was founded possesses only individual peculiarities common to an exceedingly variable form, one of which is not unfairly represented by the woodcut given in the Annals in 1848 above alluded to.

The figures of the French Great Oolite species given by M. Piette are very well executed. They are all more nearly allied to the British Great Oolite forms than are those of the Corallian rocks figured by M. Buvignier, and I will now also add, than the two Corallian forms previously figured by Sowerby, and by Young and Bird; they are, however, perfectly distinct forms, and will be readily admitted as such by any one conversant with the British Great Oolite species.

I will now offer some remarks upon the *Purpuroid* shells figured by Mr. Hudleston upon Plate VIII. of this MAGAZINE for 1880. The figures 1, 2, and 4 are assigned by Mr. Hudleston to the *Murex nodulatus* of Young and Bird. These figures are fairly well executed. I have also the advantage of possessing a large specimen of the same form kindly forwarded to me by Mr. Hudleston; this example possesses a large portion of the test of the last volution, exhibiting the pattern of the ornamentation. I have also succeeded in developing the aperture, and especially the posteal portion, and thus prove that it does not possess the internal groove of *Purpura* above alluded to. Having also a recollection of the type specimen of *Murex nodulatus* of Young and Bird, in the Whitby Museum, examined by me many years ago, I am enabled to form an opinion upon that specimen, and to arrive at the conclusion that the brief description appended to the specimen in the second edition of that work (1828) is sufficiently accurate for general purposes, and that the perpendicular undulations upon the dorsal surface, each with its two nodes or tubercles, are very characteristic of the species, and sufficiently distinct from the handsome and elaborately ornamented shell represented by the Figures 1, 2, and 4, Pl. VIII. of this MAGAZINE, and by the specimen received from Mr. Hudleston. Holding this opinion, I submitted the specimen and figures to an old friend of mine, an eminent palæontologist, who was about to visit Whitby, and gladly accepted his offer to examine for me Young and Bird's type specimen; he also has the advantage of possessing a perfect knowledge of the Gloucestershire *Purpuroidea*. In sending to me a careful tracing of the *Buccinum flammeum* (so-called in the first edition of Young and Bird's book), he says, "I saw the original specimen at Whitby, it is a rough customer, and quite distinct from the beautiful shell you showed me, the undulations are so marked in Young and Bird's specimen." I would suggest, therefore, that the materials we possess relating to the remarkable specimens of *Purpuroidea*, Plate VIII. Figs. 1, 2, and 4, are scarcely sufficient to determine the species with certainty, but that apparently they represent a new, very handsome, and very variable example of that genus to which Mr. Hudleston's name might appropriately be attached.

I will also state that I have become convinced of the distinctness of all the Yorkshire Corallian forms of *Purpuroidea* from those of the same genus in Gloucestershire, and therefore that the Great Oolite *Purpuroidea* ascribed to the *P. nodulata* of Young and Bird was an erroneous identification, excusable I think, when the great variability of the Great Oolite species is considered, and due allowance also made for the opposing difficulties to a correct knowledge of *Purpuroidea* which existed thirty or more years ago.

The front and back views of the shell upon the same Plate, 3, 3*a*, are, I am inclined to believe, correctly attributed to *Murex? tuberosus*, Sow. The supposed identity, however, rests upon the single specimen now figured, which was acquired by the late Mr. Leckenby only a short time before the transfer of his collection to Cambridge; the near resemblance which the surface ornaments bear to the *Murex nodulatus* of Young and Bird suggests the necessity for caution in deciding upon the separation or identity of those forms as species. Judging from the materials at present possessed by our museums and private collections, I am inclined to believe that the Corallian rocks of Yorkshire possess three species of our genus already figured and described: *Firstly*, the *P. tuberosa*, Sow., having a spire apparently as long as the aperture, and a subcylindrical figure of the last volution, exemplified by the very imperfect figure in the Min. Con. tab. 578, and by the shell in the Leckenby Collection, figured by Mr. Hudleston in this MAGAZINE, Pl. VIII. Figs. 3, 3*a*. *Secondly*, by the shorter spired species *P. nodulosa*, Young and Bird, of which the Whitby Museum has the type, and of which a cast may sometimes be discovered, named *Natica nodulosa*. *Thirdly*, the newly figured three specimens in this MAGAZINE, Pl. VIII. Figs. 1, 2, 4, a more ventricose species than either of the former, the spire more produced than in *P. nodulata*, and its surface more elaborately ornamented than either of the other species. The Jurassic *Purpuroidea* are limited to limestone formations. Its lowest known position is the Great Oolite of England and of France, we next discover it in the Corallian rocks of England and France, it has also lately been found in limestone of the Portland formation. The species were gregarious and appear to have occupied very limited areas both in their horizontal and vertical range. With much regret I find that at the quarry on Minchinhampton Common, which has been the most productive site for *Purpuroidea* in England, the genus is now exceedingly rare and a good specimen of any of its species has become a thing of the past generation. In the Corallian rocks a few miles to the southward of Malton, *Purpuroidea* has always been difficult to obtain excepting in the condition of internal moulds which retain no portion of the exterior surface.

After examining the figures of *Purpuroidea* already published, I would warn authors and artists to be more careful of the position of the specimen when it is intended to figure the aperture. The original woodcut (right-hand figure) published by me in 1848, although a somewhat rude engraving, exemplifies the figure of the aperture fully and accurately; it directly faces the spectator, and proves that the specimen was entirely without the groove of *Purpura*. The figure of the aperture of *Purpuroidea tuberosa* in GEOL. MAGAZINE, Pl. VIII. Fig. 3*b*, is equally satisfactory, but the aperture of the specimen, Fig. 2, upon the same Plate, has been so placed by the artist as to make the rounded columellar lip face the spectator, and conceals the more important posteal extremity of the aperture.

Of the Great Oolite of France, M. Piette's figures are similarly defective; of the three species, two apertures are given: one is decidedly without the groove of *Purpura*, the other has the posteal extremity of the aperture out of the view of the spectator. The Corallian species figured by M. Buvignier represent splendid specimens all of which are destitute of the *Purpura* groove. The apertures of *Purpuroidea* in the Great Oolite Monograph by Professor Morris and myself are not so distinct as could be wished, but exhibit nothing opposed to the views here stated.

Upon reconsideration of the Figure 2, Plate VIII., in the absence of all knowledge of the dorsal surface of the last volution and the small portion of the ornamentation exhibited upon Figure 2, I wish to limit my remarks upon the presumed new species, to the shells figured 1 and 4, also to the large specimen in my possession.

VIII.—FURTHER REMARKS ON THE ORIGIN OF THE VALLEY SYSTEM OF THE SOUTH-EASTERN HALF OF ENGLAND, PROMPTED BY THE RESULT OF A BORING NEAR WITHAM IN ESSEX.

By SEARLES V. WOOD, F.G.S.

IN a paper in the Phil. Mag. for March, 1864, "On the Formation of the River and other Valleys of the East of England," I endeavoured to show by the aid of a rough map that the whole of the hill and vale system of that part of England which lies east and south of a line drawn from the Humber to the Cotteswold Hills originated in a series of concentric arcs spreading from two centres, one of which was near Canterbury, and the other just south of the western end of the Isle of Wight; the features thus produced having been rendered more apparent by the denudation to which the disturbances gave rise, and to which both at the time, and subsequently also, these gave direction. With that map I gave hypothetical lines of section along a radius of each of these systems of concentric arcs to show the fold which, if my view of the subject was correct, should be present throughout the whole line of each arc; though of course this fold was concealed from observation, except the chance occurred of there being an open section over it; and some two years afterwards I extracted from the one mile to the inch Ordnance sheets of this part of England, and reduced upon the ten miles to the inch map, the whole of these systems of arcs in minute and accurate detail. This map was bound up along with a Geological map which I had made of South Essex in a MS. memoir on the Glacial Beds of the East of England, which I presented to the Library of the Geological Society of London, where I presume it still is.

Though in various papers subsequent to that of 1864, both in the Journal of the Geological Society and in this MAGAZINE, I have incidentally endeavoured to direct attention to the subject, the only notice with which it has met, so far as I am aware, has been an incredulous smile from geological acquaintances if I ventured to allude to it; but between five and six years ago the Committee of the Essex County Asylum, being compelled to increase their accommodation, purchased an estate at Wickham Bishop, near Witham, and commenced an artesian well on the summit of that part of one of these arcs of the Canterbury system (the 4th in the Phil. Mag. map, but the 3rd in the MS. map, counting from the centre of disturbance) which runs through that place. The sinking of this well and boring was watched by Mr. W. H. Dalton, of the Geological Survey, as part of his duty when engaged in the survey of the neighbourhood; and a section on the true scale, drawn through the ridge formed by this part of the arc, to show the peculiar and (to all but myself) unexpected position which the beds have been found to occupy in it, has lately been published by him in the "Transactions of the Epping Forest and County of Essex Naturalists Field Club"; and this shows that there is present in the ridge exactly such a fold as in the line of hypothetical section given by me I showed ought to occur everywhere along this arc, as well as along each repetition of it outwards and inwards.

I can account for the incredulity with which the facts brought forward by me more than seventeen years ago have hitherto been regarded, only by supposing that no one has thought it worth while to examine my case with that minuteness which is necessary for its realization; but now that the existence of the fold exactly at the place, and in the precise form which I thus hypothetically predicated,[1] has been found, and its discovery has involved the waste of a large sum of money (as from the failure of the strata in consequence of this fold to hold water, the Asylum Committee have been obliged to abandon their intention of using the estate for the purpose for which it was purchased), my views may now meet with a less incredulous regard than they have hitherto done. It must, however, be borne in mind that though the fold, as I contend, exists in every one of the arcs of each system, yet from its occupying not more than a hundred yards or so of horizontal space transversely to the arc (as seems to be the case at Wickham), it must everywhere be concealed, unless some open section chances to occur immediately over it. At another arc, however, of the same system as that to which the Wickham ridge belongs, viz. that which is constituted by the Cambridgeshire chalk escarpment, the occurrence of such a section has enabled the Geological Survey since my paper and map to discover a similar fold in it; and this is near Royston.

From the greater detail and accuracy with which I extracted these arcs in the MS. map annexed to the memoir in the Library of the Geological Society, I was able further to show that a third series of concentric arcs, spreading from a point of disturbance in the North Sea off Yorkshire, had, by meeting those spreading out from the Isle of Wight centre, co-operated with them in producing the valleys which crossed the arcs of the Canterbury system; and though it would be but waste of print to attempt any explanation of the features of so complex a case in this MAGAZINE, it requires but a glance at this map to perceive that all of the three sets of arcs must

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[1] See foot-note at the end of the paper.

have been due to a force which, it seems to me, can only have been steam rising obliquely at each of these three centres, and pushing the strata laterally outwards from the point where the impulse originated; causing them to fold along successive arcs, which are very much in appearance like the circles which spread out from the place where a stone is thrown into the water, save that they are not in any case complete circles. In the case of those spreading from the Isle of Wight centre they are semi-circles; but in the case of those spreading from the Canterbury centre they are only quadrants of ellipses.

Whether they agree with me or not, those gentlemen who assume to teach us the way in which mountain chains have originated, and the mode in which the disturbance of strata has come about, do most certainly remain in ignorance of one of the factors of the problem which they seek to elucidate, unless they master the details of the map which I, by presenting to the Geological Society, endeavoured to place so many years ago at their service.

In conclusion, I would observe that in the paper of 1864 I regarded the period at which these arc disturbances took place as having been the "Glacial"; and I attempted to connect with them the position occupied by the "drift" in the East of England. In his communication to which I have referred, Mr. Dalton makes the same connexion, and refers the "wave" (as he calls it) of disturbance which produced the fold at Wickham to the same period; but I long ago satisfied myself that in this I was in error, and that the movement was altogether pre-glacial; having, I think, originated under the older Tertiary sea-bed. A set of rectilinear disturbances giving rise to the highly inclined axis of the Isles of Wight and Purbeck, and to the Hogsback of Surrey, did, however, as it seems to me, take place during the Glacial submergence; and these by supervening on the anterior arc-shaped disturbances have, where they crossed the arcs, shifted the strata, and given rise to faults, such, *e.g.* as that at the western extremity of the Hogsback.[1]

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[1] These rectilinear disturbances are shown, in the map to the paper in the Phil. Mag. of March, 1864, by a different shading to that of the arc disturbances. The hypothetical line of section carried as a radius through the successive arcs of the Canterbury system (Sect. No. 2 of the Phil. Mag. plate), passes only eight miles W.S.W. of Wickham; the fold of which that now disclosed at Wickham forms part being shown in this line of section at Galleywood, but in the MS. map this is corrected by the arc being shown to pass through Danbury. The Wickham part of it is immediately north of the point where the confluence of the rivers Chelmer and Blackwater takes place in a breach through this arc, caused by the transverse action of the arcs spreading from the Isle of Wight and North Sea centres. The fold, at Royston, is part of that crossed in the radius section at Baldock, about the same distance W.S.W. of Royston that Galleywood is of Wickham. The points in the radius section at which the folds giving rise to the arc ridges should occur are shown by corresponding folds in the dotted lines over it, the character of the fold itself in hard strata, such as the chalk at Royston, and beneath Wickham, being shown by a separate diagram. In the volume of this Magazine for 1866, pp. 350-2, where I entered at some length into the subject of these arcs (connecting erroneously the movement in which they originated with the time and mode of the gravel accumulation), I drew the section (No. 9 of the plate) which I there gave across the arc in question through the Trigonometrical Station at Wickham Bishop; and showed by dotted lines

IX.—The Sudden Extinction of the Mammoth.

By Clement Reid, F.G.S.

In a valuable series of papers which have lately appeared in this Magazine, Mr. Howorth has brought together a mass of information illustrating the life history of the Mammoth. But while we must thank him for the labour he has undertaken in collecting these facts, many from little known authorities, I venture to suggest that some of his conclusions ought not to be allowed to pass without a strong protest.

The paper published in the Geol. Mag. for July shows a reversion to the old and, I had hoped, extinct theory of violent changes and the sudden extermination of a species over large areas in a few days. The facts Mr. Howorth brings forward I do not challenge: wherever I have been able to check them they show the greatest accuracy and fairness of statement. But the conclusions he draws seem quite unwarranted by the facts, and are thoroughly opposed to the view of most modern geologists, that vast changes need a great lapse of time. If the occasional preservation of carcases of the mammoth and rhinoceros in frozen soil can be explained otherwise, I think we are not justified in bringing into play a permanent lowering of the temperature through many degrees, only taking a few days, or perhaps weeks, to complete.

From the character of the mammaliferous deposits in Siberia it is evident that they cannot have been frozen all at once or through radiation from the present surface, for interstratified with the mud are numerous sheets of clear ice, which must have been successively formed.

It seems probable that such alternating beds of frozen soil and ice might well be formed in Siberia even when the climate was rather warmer than at present and could support the vegetation necessary for the existence of large mammals. The plants found associated with the mammoth do not appear to show a warm climate, but merely one rather warmer than at present, and probably very similar to that of the Hudson's Bay territory.

During the Siberian winter the alluvial soil and the ponds become frozen, and in the spring the thawing of the rivers near the source before the mouth is clear of ice, as Lyell explains, causes floods. These floods of ice-cold water would, I believe, throw down a fresh layer of sediment, which would protect the underlying one from the summer heat, and afterwards itself freeze with any included animals. This process might go on in a climate considerably warmer than Siberia is at the present day, as long as the necessary condition of the deposition of fresh protecting layers of sediment occurred, or

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the fold ("great flexure, or rolling earthquake surge," I there termed it) over the very site where the well-boring made 12 years afterwards disclosed its existence. Being entirely concealed, there was nothing in the position of the beds anywhere as disclosed by sections, or any antecedent borings in the neighbourhood, to induce the least suspicion of the existence of this fold. Mr. Dalton shows a fault passing through the Wickham fold; but it seems to me that what he brings in the fault to account for is due to a sinuosity in the fold only.

failing that, the mean temperature of the air did not rise to near the freezing-point. That such preservation of masses of ice is quite possible is shown by their occurrence under the lava of Etna, and often at the foot of cliffs under talus on which vegetation has afterwards grown.

If I understand rightly the published descriptions of the frozen tundras, they are simply another instance of flood deposits now permanently dry, through the lowering of the river-beds, in this respect corresponding with the Rhine loess and probably with the Thames Valley brick-earths. The whole country being formed of flood deposits, it is not surprising that the bones are now constantly found in hills much above the present river-level, for there appears to be evidence that at the time of the formation of the Tundras, the sea-level was a good deal higher than at present, the deposits on the lower lands near the sea being marine or estuarine. When the fall of the river was less than at the present day, the floods would necessarily rise to a greater height.

NOTICES OF MEMOIRS.

I.—On the Laurentian Beds of Donegal and of other Parts of Ireland. By Professor Edward Hull, LL.D., F.R.S., etc., Director of the Geological Survey of Ireland.

After a perusal of the writings of previous authors, and a personal examination made in the spring of 1881, in company with two of his colleagues of the Geological Survey, Mr. R. G. Symes, F.G.S., and Mr. S. B. Wilkinson, the author had arrived at the following conclusions.

1st. That the Gneissose series of Donegal, sometimes called "Donegal Granite," is unconformably overlaid by the metamorphosed quartzites, schists, and limestones which Professor Harkness had shown to be the representatives of the Lower Silurian beds of Scotland (Quart. Journ. Geol. Soc., vol. xvii. p. 256). This unconformity is especially noticeable in the district of Lough Salt, near Glen.

2nd. That the Gneissose series is similar in character and identical in position and age with the "Fundamental Gneiss" (Murchison) of parts of Sutherlandshire and Ross-shire, and is, therefore, like the latter, presumably of Laurentian age. That the formation is a metamorphosed series of sedimentary beds, had been shown by Dr. Haughton and Mr. R. H. Scott.

3rd. That the north-western boundary of the Donegal Gneiss is a large fault between the Laurentian Gneiss and the metamorphosed Lower Silurian beds, owing to which the older rocks have been elevated, and by denudation have been exposed at the surface.

4th. That the Cambrian formation of Scotland is not represented in Donegal, and that the unconformity above referred to represents a double hiatus, and is of the same character as that which occurs in Sutherlandshire, in the district of Foinaven and Ben Arkle, where the Lower Silurian beds rest directly on the Laurentian Gneiss.

5th. That Laurentian rocks may be recognized in other parts of Ireland, as in the Slieve Gamph and Ox Mountains of Mayo and Sligo, at Belmullet, and in West Galway north of Galway Bay, where the rocks consist of red gneiss, hornblende rock, and schist, etc., similar to those in Donegal; also possibly in Co. Tyrone, as suggested by Mr. Kinahan.

II.—OBSERVATIONS ON THE TWO TYPES OF CAMBRIAN BEDS OF THE BRITISH ISLES (THE CALEDONIAN AND HIBERNO-CAMBRIAN), AND THE CONDITIONS UNDER WHICH THEY WERE RESPECTIVELY DEPOSITED. By Professor EDWARD HULL, LL.D., F.R.S., etc.

IN this paper the author pointed out the distinctions in mineral character between the Cambrian beds of the North-West Highlands of Scotland, and their assumed representatives in the East of Ireland and North Wales and Salop. In the former case, which included the beds belonging to the "Caledonian type," the formation consists of red or purple sandstones and conglomerates; in the latter, which included the beds belonging to the "Hiberno-Cambrian type," the formation consists of hard green and purple grits and slates, contrasting strongly with the former in structure and appearance.

These differences, the author considered, were due to deposition in distinct basins, lying on either side of an Archæan ridge of crystalline rocks, which ranged probably from Scandinavia through the Central Highlands of Scotland, and included the North and West of Ireland, with the counties of Donegal, Derry, Mayo, Sligo, and Galway, in all of which the Cambrian beds were absent, so that the Lower Silurian repose directly and unconformably on the crystalline rocks of Laurentian age.

As additional evidence of the existence of this old ridge, the author showed that when the Lower Silurian beds were in course of formation, the Archæan floor along the West of Scotland must have sloped upwards towards the east, but he agreed with Professor Ramsay, that the crystalline rocks of the Outer Hebrides formed the western limit of the Cambrian area of deposition, and that the basin was in the form of an inland lake.

On the other hand, looking at the fossil evidence both of the Irish and Welsh Cambrian beds, he was of opinion that the beds of this basin were in the main, if not altogether, of marine origin, and that the basin itself had a greatly wider range eastward and southward, the old Archæan ridge of the British Isles forming but a small portion of the original margin.

The beds included in the above represent the Llanberris and Harlech beds, those of the Longmynd and of St. Davids, in which a remarkable primæval marine fauna had been discovered by Dr. Hicks.

III.—The Devono-Silurian Formation. By Professor E. Hull, LL.D., F.R.S., etc.

THE beds which the author proposed to group under the above designation are found at various parts of the British Isles, and to a slight extent on the Continent. The formation is, however, eminently British, and occurs under various local names, of which the following are the principal :—

England and Wales.

Devonshire.—'The Foreland Grits and Slates,' lying below the Lower Devonian beds ('Lynton Beds').

Welsh Borders.—'The passage beds' of Murchison, above the Upper Ludlow Bone bed, and including the Downton Sandstone, and rocks of the Ridge of the Trichrug. These beds form the connecting link between the Estuarine Devonian beds of Hereford (generally, but erroneously, called the 'Old Red Sandstone') and the Upper Silurian Series.

South-East of England (Sub-Cretaceous district).—The author assumed, from the borings at Ware, Turnford, and Tottenham Court Road, described by Mr. Etheridge, that the Devono-Silurian beds lie concealed between Turnford and Tottenham Court Road on the south, and Hertford on the north.

Ireland.

South.—'The Dingle Beds,' or 'Glengariff Grits and Slates,' with plants and fucoids, lying conformably on the Upper Silurian Beds, as seen in the coast of the Dingle promontory, and overlaid unconformably by either Old Red Sandstone, or Lower Carboniferous Beds; 10,000 to 12,000 feet in thickness.

North.—'The Fintona Beds,' occupying large tracts of Londonderry, Monaghan, and Tyrone, resting unconformably on the Lower Silurian beds of Pomeroy, and overlaid unconformably by the Old Red Sandstone, or Lower Carboniferous Beds; 5,000 to 6,000 feet in thickness.

Scotland.

South.—Beds of the so-called 'Lower Old Red Sandstone' with fish and crustaceans, included in Professor Geikie's 'Lake Orcadie, Lake Caledonia, and Lake Cheviot,' underlying unconformably the Old Red Sandstone, and Lower Calciferous Sandstone, and resting unconformably on older Crystalline rocks. Thickness in Caithness about 16,200 feet.

The author considered that all these beds were representative of one another in time, deposited under lacustrine or estuarine conditions, and, as their name indicated, forming a great group intermediate between the Silurian, on the one hand, and the Devonian, on the other. He also submitted that their importance, as indicated by their great development in Ireland and Scotland, entitled them to a distinctive name, such as that proposed.

IV.—SECOND REPORT OF THE COMMITTEE, CONSISTING OF PROFESSOR P. M. DUNCAN AND MR. G. R. VINE, APPOINTED FOR THE PURPOSE OF REPORTING ON FOSSIL POLYZOA. Drawn up by Mr. VINE (Secretary).

(Continued from p. 477.)

1844. MYRIAPORIDÆ, M'Coy. Family name only.

This is the third family of M'Coy's very restricted classification of Palæozoic Polyzoa. It embraces the *Retepora*, Lamk. = to *Elasmopora*, King. The family includes *Glauconome*, Goldfuss, restricted by Lonsdale, and the genus *Fenestella*, Lonsdale. It is impossible to retain the family name in the present Report.

1849. *Phyllopora*, King.

There are unquestionably present in both the American and British Palæozoic rocks, species of Polyzoa having some of the inosculating characters of *Retepora cellulosa*. These can neither be referred to *Fenestella* nor *Polypora*. My objections to the term *Retepora* for these have already been expressed. King, also, in his Permian Fossils, has expressed his dislike to this term, and he suggests another word to be used instead—*Phyllopora*. I prefer this, especially as it has been consecrated by two good workers—Salter and De Koninck. The earliest appearance of the genus, so far I am acquainted, is in Lower Llandeilo flags at Ffairfach. The species is unnamed, and it forms one of the specimens of the Wyatt-Edgell collection. The general habit of the specimen is somewhat like *Retepora*. We have only the reverse of a portion of the zoarium, but in several places the branches are worn and the cells exposed, but not with sufficient distinctness to make out their actual structure. The fenestræ are oval and irregular, and the branches anastomose without dissepiments. A fine large specimen—reverse only—of this type is marked "*Bryozoa*," in case vii. $\frac{6}{44}$ of the School of Mines, and as "*Bryozoon*" in the "Catalogue of Cambrian and Silurian Fossils," p. 105. All the other specimens are very fragmentary, but in the Devonian series there is a matrix of a very fine species. If better fragments could be found in the Devonian rocks, good facilities for the closer study of this type of Palæozoic Polyzoa would be offered.

De Koninck refers two specimens, doubtfully, to this genus[1]—*P. ? Haimeana*, De Kon.; and *P. ? cribellum*, De Kon. These are amongst the Indian Fossils of Dr. Fleming. In the monograph of Permian Fossils Mr. King refers, and fully describes, *P. Ehrenbergi*, Geinitz, as belonging to this genus. In his paper on the Permian rocks of South Yorkshire,[2] Mr. Kirkby refers fragments of the same species to *Retepora Ehrenbergi* (*Phyllopora*). The genus is a comparatively rare one, and well-authenticated specimens are also rare. To this genus I refer Nicholson's species[3] *Phyllopora* (*Retepora*)

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[1] Quart. Journ. Geol. Soc. vol. xix. 1862.

[2] Journ. Geol. Soc. vol. xvii. 1861.

[3] GEOL. MAG. Jan. 1875, Pl. II. Figs. 4–4*b*.

Trentonensis. It is well described, seeing that his specimens were mere fragments. Salter has already referred to this genus—M'Coy's *Retepora* (*Phyllopora*) *Hisingeri*—in his Catalogue of Silurian Fossils.

1821? *Berenicea,* Lamaroux.

This genus for the present I have allowed to remain with the family *Diastoporidæ*[1]—not as *Diastopora,* but as provisional. So far as the Palæozoic species are characteristic of the genus, we may take M'Coy's description.[2] He says, "The cells resemble *Cellepora,* but are not piled," but, with more justness, "they also resemble the cells of *Stictopora* (*Ptilodictya*), but are parasitic and confined to one side. They differ from *Discopora* by each cell being separated by a small space from its neighbour." *Berenicea irregularis,* Lonsdale (Silurian Sys.), and *B. heterogyra,* M'Coy, are distinct types. The *Discopora favosa,* Lonsd., Wenlock Limestone, approach nearer to the *Ceramopora* type of Hall and Nicholson.[3]

1828. *Discopora,* Flem.?

Two types of this genus, as understood by Lonsdale, are found in the Wenlock series of Fossils at the School of Mines. One, *D. favosa,* Lonsd., is a beautiful little dome-like species with cells very regularly disposed radiating from the centre. The other is much larger and marked *Discopora favosa?* Lonsd. Both are good types, and they will ultimately find their proper place in our classification. But as *Discopora* (*Patinella* and *Discoporella* of Busk) it will be at present impossible to retain them, unless under very severe limitation.

1849. FENESTELLIDÆ, King.

After the three very able papers of Mr. G. W. Shrubsole, F.G.S., it will be useless to dwell too long upon this family. With the whole of Mr. Shrubsole's work I am inclined, generally, to agree. He may be blamed for the limitation of species, but the fault lies not with him, but with authors who have introduced into our scientific literature specific names for fragments that were really portions only of other species. This has already been pointed out, but much yet remains to be done before the family can be considered to be completely revised. It may then be necessary to reintroduce one or two species which are now regarded as synonyms, and also to establish two or three new ones. For the present I can do no other than report on the literature and species which have not yet found a place in the revisions of Mr. Shrubsole.

Gorgonia assimilis, Lonsd., Murch. Sil.
Fenestella ,, Cat. Cambrian and Sil. Fos. S. of M.

This species has been alluded to in Mr. Shrubsole's second paper (p. 247). In the above catalogue it may be found among the Caradoc and Wenlock Limestone series of Polyzoa. This species has not been described, and there seems to be a doubt whether it should be referred to *Fenestella* or *Retepora* (*Phyllopora*).[4]

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[1] Q. J. Geol. Soc. Aug. 1880. [2] Palæozoic Fos. [3] GEOL. MAG. 1874-5.

[4] "A Review of the Carb. Fenestellidæ," Quart. Journ. Geol. Soc. May, 1879; "A Review of the Various Species of Upper Sil. Fenestellidæ," Quart. Journ. Geol. Soc. 1880; "Further Notes on Carb. Fenestellidæ," *ibid.*

Many of the earlier specimens—Caradoc and Upper Llandovery—are very indistinct, and complete identification seems to be impossible. The type is a peculiar one, but after going over the specimens I can make out the following characters. The zoarium is irregular and dichotomously branching, no regular dissepiments or fenestræ. The frequent bifurcations of the branches, by impinging upon the lower branches, are the only means by which fenestræ are formed; the number of pores on either side of these vary from ten to thirteen. I cannot therefore suppose that these earlier *Fenestella assimilis* of the Catalogue are in any way related to *Fenestella reteporata*, Shrubsole, of the Wenlock Limestone. So far as I am able to judge from the specimens, they are totally distinct.

The whole of the type specimens of Upper Silurian *Fenestella* Mr. Shrubsole has gone over carefully; but as many of these were mere fragments of the reverse, showing no cell-arrangement, he found them altogether valueless for accurate definition. In consequence of this revision the whole of the Upper Silurian FENESTELLIDÆ is put down by him as follows:—

Fenestella rigidula, M'Coy, Brit. Pal. Fos. p. 50, pl. i. C. fig. 19.
,, *reteporata*, Shrubsole, Quart. Journ. Geol. Soc. May, 1880.
,, *lineata* ,, ,, ,, ,, ,,
,, *intermedia* ,, ,, ,, ,, ,,

All these species are found in the Wenlock Limestone, Dudley, and two of them—if not three—in the Niagara Limestone, Lockport, America.

Of the Devonian *Fenestella* but few species are recorded. But as Professor Nicholson has published his papers in this country, we are largely indebted to him for what little is known, besides those that are figured and described by Goldfuss and Phillips.

1826–33. *Retepora* (*Fenestella*) *prisca*, Goldf.,[1] Eifel.
,, ,, ,, *antiqua* ,, ,,
1841. *Fenestella antiqua*; *anthritica*; and *Hemitrypa oculata*, Ph.[2]
1874. *Fenestella magnifica*, Nichol. GEOL. MAG. 1874, Pl. IX.
,, ,, *marginalis*, ,, ,, ,, ,, ,,
,, ,, *filiformis* ,, ,, ,, ,, ,,
,, ,, *Retepora* (*Fenestella*) *Phillipsi* ,, ,,

Many, if not all, of these species are founded upon fragments, or on the reverse only of specimens; and according to the laxness or rigidness with which they are examined, their value in a scientific criticism is of variable importance. They are nevertheless links in the chain of evidence, and until they are displaced by better specimens, which, of course, will allow of better work, they should find a place in this Report. Nicholson, with others, uses the term *Retepora* very indifferently. Speaking of *R. Phillipsi*, he says, "This is a genuine *Retepora*, and in its general form and its biserial cells is closely allied to *R. prisca*, Goldf., which I have found abundantly in

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[1] Petrefac. Ger. tab. 36, fig. 19, tab. 9, fig. 10.

[2] Phillips' Palæ. Fos. Devon, etc.

the Corniferous Limestone of Ontario." As I have already placed Goldfuss's *R. prisca* with the FENESTELLIDÆ, I cannot do otherwise with this one.

In addition to these species, Nicholson founds two new genera for Devonian *Fenestella* :—

1874. *Cryptopora*, Ann. Mag. Nat. Hist., Feb. 1874.
,, *Carinopora* ,, ,, ,,

Two species—*Cryptopora mirabilis*, Nich., and *Carinopora Hindei* —Nicholson places to these new genera. With all due respect for Professor Nicholson and his work, I must take his admission that these are apparently *Fenestellidæ*, and as such there was, I am inclined to think, no need for founding new genera for their reception. The author refers to *Hemitrypa*, and, in one sense, compares his genera with the genus of M‘Coy. Unfortunately for the fate of all three genera, we have only true *Fenestella* encrusted by a coral, and the diagnosis of the species given by both authors is encumbered with partly corallite and partly polyzoal structures. All the illustrations which Professor Nicholson gives are structures found in typical *Fenestella*,[1] with the exception of fig. 2 *g*, p. 81. Here the "carina," or keels, are apparently united by "stolons," which may be sections of the tabulæ only of the encrusting coral. Fig. *f* is without this "stoloniferous" connexion, but both are sections of branches cut through perpendicular to the surface, and showing the largely developed keel, with the transverse section of the cells. Fig. *i* is one of these, isolated. It would be better to view the structures reversed. Figs. *d* and *e* are evidently ordinary *Fenestella*, and the sections above described are portions of the same frond.[2] The development of the keel is remarkable, and speaking of *C. Hindei* Nicholson says, "The thickness of the frond, measured at right angles to its plane of growth, is one line or a little more, nearly two-thirds of this being accounted for by the great internal keels." This is equalled by the species *F. Lyelli*, Dawson, which is figured and partly described in "Acadian Geology."[3]

1826–33. *Glauconome disticha*, Goldf., Petr. Germ.
1874–5. *Ramipora*, Toula, Permo-Carbon. Fossilien.[4]
? 1878. ,, *Hochstetteri*, Toula, Bigsby, Devon. Carbon.
,, ,, var. *carinata*, R. Etheridge, jun., GEOL. MAG. 1879.

I arrange these genera and species, not because they are allies, but because they are the reverse of that. The genera are as distinct as genera can be, yet they have been confounded by authors. The *G. disticha* of Goldfuss is, I think, distinctly an Upper Silurian type. The Bala type of *Glauconome?* is a different genus; and *Ramipora*, as described by Toula, has five or six rows of irregular pores. The genus *Ramipora* is a Permo-Carboniferous type, and although having

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[1] See the illustration in the Ann. Mag. Nat. Hist. Feb. 1874.

[2] I wish the reader to refer to Nicholson's paper as given above.

[3] Carb. Limestone, pp. 288-9.

[4] See Arctic Pal. Polyzoa, R. Etheridge, jun, 1878, Journ. Geol. Society.

some facial resemblance to the species from the Bala beds, and figured as *Ramipora*, var. *carinata*, Eth., jun.,[1] by Mr. Robert Etheridge, jun., the two forms differ in many respects considerably. *Ramipora* is much larger naturally than the Bala *Glauconome;* the cells are differently arranged. In the Lower Silurian species, both the primary and the secondary branches bear two rows of alternately arranged cells. Having handled and carefully examined the specimen in the School of Mines, figured by Mr. Etheridge, I can bear willing testimony to the faithful delineation of this beautiful type.

There are several specimens of this as yet undescribed genus in the collection already named, and their study will afford a good general idea of the varying habit of the species.

1844. *Polypora*, M'Coy.

Zoarium a delicate, reticulated, calcareous expansion. Branches round, from three to five rows of cell-openings—margins usually not projecting, branches connected (occasionally) by thin dissepiments.

This genus is represented by only one species, *P. ? crassa*, Lonsd., in the Wenlock Limestone, Dudley. The genus was more fully represented in America in the Devonian strata, and in our own country;—in the Arctic regions;—and India during the Carboniferous epoch. Professor Nicholson[2] describes and figures three species: *P. pulchella*, Nich., *P. tenella*, Nich., *P. tuberculata*, Nich. As a *P. tuberculata* has been previously described by Prout,[3] the name of Nicholson is rather unfortunate, as there is a difference in the two species, for Nicholson says his is allied to *P. venucosa*, M'Coy, and as such it differs from Prout's *P. tuberculata*, if the identification of the Messrs. Young be correct. *P. pulchella* and *P. tenella* are nearly allied to *P. Halliana*, Prout, which occurs "in the St. Louis Group of Illinois, and which I have likewise detected in the Corniferous formation of Ontario."—Nicholson.

I have now gone over all the genera wherein the cell-characters are either ovate or sub-tubular, without saying arbitrarily that these genera and species belong to the Cyclostomata. I have begun with the species having the nearest apparent affinities with the Cheilostomata, and then allowed the others to fall in, in a consecutive order. This temporary arrangement will be better for the present, and this will allow time for a proper classification when the whole of the Palæozoic Polyzoa have been more closely studied. The following genera I have not the least hesitation in placing with the *Cyclostomata* as at present understood.

1859. Cyclostomata, Busk.

"Cell tubular; orifice terminal, of same diameter as the cell, without any moveable apparatus for its closure; consistence calcareous."[4]

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[1] Geol. Mag. 1879.

[2] New Devonian Fossils, Geol. Mag. 1874.

[3] Trans. of Acad. of Science, St. Louis, Geol. Mag. June, 1874.

[4] Monograph of the Crag Polyzoa, p. 9.

1825. *Stomatopora*, Bronn.
1821. *Alecto*, Lamx. 1826. *Aulopora* (pars), Goldfuss.

"Zoarium closely adnate throughout, simple or irregularly branched; branches linear or ligulate; cells disposed in a simple series or in more or less regular transverse rows of from two to four."[1]

A few types of this genus are present in the Palæozoic rocks of this country—in the Devonian of Eifel—and in America.

James Hall, in his Pal. of New York, vol. i., records the existence of *Alecto inflata* in the Trenton Limestone. This is a very simple serial species of a most remarkable type. From the same stratum he records another species, *Aulopora arachnoidea*, altogether different from the first type. Except that Hall calls these species "corals," there is not in his descriptions any characters that would prevent them being properly placed with the Polyzoa. I have already alluded to this species *A. inflata*, Hall, when writing of *Hippothoa.* I now restore it to its proper place.

1874. *Alecto auloporides*, Nich.[2]
,, *frondosa* = *Aulopora frondosa*, James.
1874. ,, *confusa*, Nich.

These seem to be true *Stomatopora* (*Alecto* of Busk), and their existence is recorded by Nicholson as appearing in the Lower Silurian or Hudson River Group. One species, *A. auloporides*, as a branching form survives into the Niagara Limestone. In the Caradoc series of Fossils in the School of Mines, a small specimen of Polyzoa is marked *Heteropora*, allied to *H. crassa.*[3] This is a very peculiar species, but in no way related to *Heteropora* as now understood. The cells are short and tubular, alternately placed on the sides of the branch, very similar to the figure given by Nicholson. Having carefully examined the specimen, I therefore—temporarily—place it as a variety, at least, of *Stomatopora auloporides*, Nich.

I have, since the above was written, discovered no less than three distinct types of *Stomatopora* in the Up. Silurian Shales of Shropshire. One I have figured and described—*S. dissimilis*, Vine.[4] The others I have not yet sufficient details to allow of full description. I have also discovered two species of *Ascodictyon*,[5] full details of which will be published. In King's Monograph of Permian Fossils, pl. 3, fig. 13, a figure is given of—apparently—a badly preserved specimen of *Stomatopora*. It very much resembles the species of Hall, but no cell-mouths are given. King names it *Aulopora* (*Stomatopora*) *Voigtiana*, King.

1839. *Diastopora* (*Aulopora*) *consimilis*, Lonsd.

A species of Polyzoa, named as above, is in the Ketley Collection at the School of Mines. It is found in the Wenlock Limestone Series, but no locality is given. This is the *Aulopora consimilis*,

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[1] Busk, *Cyclostomata*, p. 22.
[2] Paper read at Brit. Assoc. Belfast; printed, Ann. Mag. Nat. Hist. 1875.
[3] Catalogue of Silurian Fos. p. 44, case vii. $\frac{4}{67}$.
[4] Geol. Soc. Pap. read June 22, 1881.
[5] Nicholson, Ann. Mag. Nat. Hist. June, 1877.

Lonsd., of the Silurian System, pl. 15, fig. 7. I have found fragments in the washings of Mr. Maw.[1] Another specimen of the same species, from the Wenlock Limestone, Dudley, encrusting a small coral, is in the cabinet of Mr. Longe, F.G.S., of Cheltenham. In the Devonian collection of Polyzoa, at the School of Mines, a species marked *Berenicea M'Coyii*, Salter, Middle Devonian, Padstow, bears a very close resemblance to this Silurian type. Unfortunately the Devonian specimen is very poorly preserved, but I can trace in the zoarium a sufficient number of cells to afford me some idea of the general character. The specimen in Mr. Longe's cabinet I have carefully studied, and I now give a description with very accurate measurements.

Zoaria encrusting by a single layer a fragment of coral. *Zoœcia* tubular, rather regular, in series. As several colonies are found upon the same coral, a remarkably irregular character is given to the associated *zoaria.* For the purpose of this diagnosis I isolate a single colony. Cell-mouths circular, with a well-formed peristome, and slightly less than the diameter of the tubes. Six *zoœcia* occupy the space of a line measured across the mouth of the cells, and two and half, to three, lengthwise in the same space.[2]

The habit of Lonsdale's species in the School of Mines, and also Salter's Devonian *Berenicea,* is that of the ordinary *Diastopora.* The habit of the species here described, and also the measurements, correspond with Nicholson's *Alecto confusa.* If these be true *Diastopora*—for I cannot ignore the existence of *D. consimilis* and *Berenicea M'Coyii*—we have a true tubular *Diastopora* carried backward in time to the Wenlock Limestone; consequently the *Berenicea* which I left provisionally with the *Diastoporidæ*[3] will be displaced by undoubted tubular species. The measurement of *Alecto confusa*, Nich., is five cells to the line, measured across the mouth.[4] This is slightly less than my own, and may be accounted for by the more compact arrangement of the cells in the Dudley specimen.

1826. *Ceriopora*, Goldfuss.

Several species of this genus are given as Up. Silurian by authors,

Ceriopora affinis, Goldfuss.
" *granulosa*, "
" *punctata*, "

and Nicholson in his New Devonian Fossils adds *Ceriopora*? *Hamiltonensis*, of which he says, "This beautiful little fossil (about five cells occupy the space of a line vertically) occurs in great abundance

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[1] In plate 15, Silurian System, reproduced as pl. xli., Silurian, ed. 1859, marked 7. *Diastopora ? consimilis*, probably a Bryozoon.

[2] This was written in December, 1880, a copy of which was furnished shortly after to Mr. Longe, for his correction and approval for publication in this Report, as *Alecto confusa*, Nicholson ? var. *regularis*. I have seen since that a paper has been furnished for reading on *Diastopora*, at the Geol. Soc. May, 1881. I have no desire to press my own name in preference to his, seeing that I wrote my description previously to the examination of Lonsdale's and M'Coy's Silurian and Devonian species in the School of Mines.

[3] Review of the Fam. *Diastoporidæ*, Quart. Journ. Geol. Soc. Aug. 1880.

[4] Nicholson does not say this, but I infer it from his remarks.

in some of the beds of the Hamilton Formation. It is allied to *C. punctata*, Gold., and *Millepora interporosa*, Phill. (Geol. of York). I am at present unable to decide as to its true generic affinities, and have simply referred it provisionally to *Ceriopora*." I will also leave it and the other species alone for the present. The whole of the *Cerioporidæ* will have to be revised, and species from the Silurian to the Crag will have to be re-worked.

1821. *Spiropora*, Lamx.

In some of the shale-washings supplied to me by Mr. Maw from strata below the Wenlock Limestone, I have come across many beautiful fragments of this genus, which will enable me to carry back the type to Silurian times. Mr. Ralfe Tate has already carried back the genus to the Lias,[1] but the specific differences between the Liassic and Silurian forms are very marked. The Silurian species I shall describe under the name of *Spiropora regularis*, Vine.

1874. *Botryllopora*, Nicholson.[2]

This curious genus, founded by Nicholson for Devonian species, is allied to *Defrancia* and *Lichenopora*, but unlike either. The author says, "I have been unable to refer these singular Polyzoa to any existing group, and have therefore been compelled to found a new genus for their reception. Zoarium calcareous, sessile, and encrusting, forming systems of small circular discs, the upper surfaces of which are marked with radiating ridges, upon which the cells are carried. Each disc is attached by its entire lower surface, slightly convex above, with a central nonporiferous space, round which a number of radiating poriferous ridges occupy an exterior, slightly elevated zone. Cells forming a double series on each ridge, immersed with rounded mouths, which are not elevated in any part of their circumference above the general surface." [3]

One species is given, *B. socialis*, Nich. pl. ix. fig. 16, and it is not of very rare occurrence in the Hamilton Formation. I have not seen among any of our own Palæozoic Polyzoa any approach to this genus. It may be well to direct attention to the characters, because workers may find even this amongst the group of our hitherto most neglected fossils.

In my first Report ("British Carboniferous Polyzoa," 1880[4]) I said that "to the Palæontologist the study of the Palæozoic Polyzoa opens up many very important biological details; for the connexion of the Polyzoa with the Graptolites is a question that must be dealt with in detail."

Since this was written I have gone over much that has been written in this country on this debatable subject. Professor Huxley, Mr. Salter, and Professor H. Alleyne Nicholson have severally occupied themselves with this question of affinity. Mr. Salter says, "I think Professor Huxley first suggested the resemblance to *Defran-*

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[1] *Spiropora liassica*, Tate, Geol. Mag. 1875.

[2] Canadian Journ. No. 80; Geol. Mag. 1874, p. 23.

[3] *Ibid.* p. 23.

[4] British Association Reports.

VERTICAL RANGE OF SILURIAN POLYZOA OR SPECIES DESCRIBED.

MUSEUM OF PRACTICAL GEOLOGY; SILURIA AND SILURIAN SYSTEM.

Genus.	Species.	Author.	Formation.	Catalogue page.	My own Collection marked *
Phyllopora	sp.	... ...	Lower Llandeilo	20	
Ptilodictya	*dichotoma*	Portlock	,, ,, ...	,,	
,,	,, ...	,, ...	Upper ,, ...	28	
Fenestella	sp.	... ...	,, ,, ...	,,	
Diastopora ?	*heterogyra* ...	M'Coy, *Berenicea*	Caradoc ...	44	*
Fenestella	*assimilis*	Lonsdale	,, ...	,,	
,,	*Milleri*	,, ...	,, ...	,,	*
,,	*regularis* and sp.	Portlock	,, ...	,,	
Glauconome	*disticha* (?) ...	Goldfuss.	,, ...	,,	*
Heteropora ?	*Alecto confusa* type	Nicholson ...	,, ...	,,	
Phyllopora	*Hisingeri*	M'Coy	,, ...	,,	*
,,	*ornata*	MS., Wyatt Edg.	,, ...	,,	
Ptilodictya	*acuta*	Hall	,, ...	45	
,,	*dichotoma* ...	Portlock	,, ..	,,	*
,,	*explanata*	M'Coy	,, ...	,,	*
,,	*papillata*	MS., Etheridge	,, ...	,,	
,,	*ramosa*	,,	,, ...	,,	
,,	*recta*	Hall	,, ...	,,	
,,	*scutata*	MS., Etheridge	,, ...	,,	
Retepora ?	*ramosa*	Hisinger	,, ...	,,	
Fenestella	sp.	... ...	Lower Llandovery	64	
Glauconome	*innexa*	Salter	,, ,, ...	,,	
Phyllopora	sp.	... ...	,, ,, ..	,,	
Ptilodictya	*fucoides*	M'Coy, cast of cells only ...	,, ,, ...	,,	
Fenestella	*sub-antiqua* ...	D'Orb.	Upper ,, ...	72	
Ptilodictya	*lanceolata* (*Lonsdalii*, Vine) ...	Lonsdale	,, ,, ...	,,	*
,,	*scalpellum* ...	,, ...			
Fenestella	sp.	... ...	Wenlock Shales [1]	85	*Stomatopora dissimilis*, Vine.
Ptilodictya	*lanceolata* ...	,, ...			
Ceriopora	*oculata*	Goldfuss	Wenlock Limestn.	104	*
Diastopora	*consimilis* ...	Lonsdale	,, ,, ...	,,	*From W. Shale.
Discopora	*favosa*	,, ...	,, ,, ...	,,	*
Fenestella	*assimilis* ? ...	,, ...	,, ,, ...	,,	*F. intermedia*, Shrub.*
,,	*Lonsdalii* ? ...	D'Orb.	,, ,, ...	,,	*F. reteporata*, Shrub.*
,,	*Milleri* ?	Lonsdale	,, ,, ...	,,	*F. lineata*, Shrub.*
,,	*reticulata* ? ...	,, ...	,, ,, ...	,,	
,,	*rigidula*	M'Coy	,, ,, ...	,,	
,,	*sub-antiqua* ...	D'Orb.	,, ,, ...	,,	
Glauconome	*disticha*	Goldfuss.	,, ,, ...	105	*
Polypora ?	*crassa*	Lonsdale	,, ,, ...	,,	*
Ptilodictya	*lanceolata* ...	Goldfuss.	,, ,, ...	,,	*
,,	*scalpellum* ...	Lonsdale			
Phyllopora	marked *Bryozoon*	Reverse only ...	,, ,, ...	,,	*Berenicea irregularis* Lonsdale*
Ceriopora	*oculata*	Goldfuss.	Lower Ludlow ...	119 [2]	
Diastopora	*Berenicea* sp. ...	... ...	,, ,, ...	,,	
Ptilodictya	*lanceolata* ...	Lonsdale [3] ...	,, ,, ...	,,	
,,	*lanceolata* ...	,, ...	Aymestry Limest.	125	
Ceriopora	*granulosa* ...	Goldfuss.	Upper Ludlow ...	131	
Discopora	sp.	... ...	,, ,, ...	,,	
Ptilodictya	n. sp.	... ...	,, ,, ...	,,	

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[1] From these shales I have obtained several specimens of species of *Stomatopora*, *Ascodictyon*, 2 sp., and *Spiropora*, 2 sp. Species also of *Ptilodictya Lonsdalii*, *P. scalpellum*, *Polypora ? Glauconome*, and *Ceriopora*, etc.

[2] I have several other unworked species of Polyzoa from the Wenlock Limestone series.

[3] This is more of the type *P. lanceolata*, Goldfuss.

cia;"[1] his own opinion, however, was very decidedly expressed. "The point I would chiefly call attention to is that there is a complete series up to the most compound in this remarkable family;" and after pointing out the varied features of the leading types of the *Graptolitidæ*, he concludes by saying, "*Dendrograptus* has the branches numerous, unsymmetrical, and crowded, while *Dictyonema* completes the series by showing the numerous rod-like stems each with their cells in double rows, connected by numerous transverse bars into a network like that of *Fenestella*, to which, indeed, I believe it forms the passage group."[2] Professor Nicholson, after examining in detail the various points raised by Mr. Salter, says, "The 'polyzoarium' (of the Polyzoa) is commonly more or less highly charged with lime, and this is especially the case with the fossil forms. The polypary of the Graptolites, on the other hand, are invariably corneous (or chitinous)."[3] Notwithstanding these varied opinions, I very reluctantly reviewed the whole of the points mooted by Nicholson and others, and then submitted my notes to Mr. Lapworth's scrutiny before publication. He has gone over every one of these notes critically, and, as his decision is adverse to my own views (founded to a large extent upon facial resemblances), I cannot do otherwise than bow to his dictum. "If the Polyzoa and the Graptolithina had a common ancestor—a view I have always been disposed to adopt myself—it must have existed at an antiquity far more greatly removed from Silurian time than Silurian time is from our own ages; for the differences which then separated the two groups appear to have been almost as gigantic in importance as those which divide the Hydrozoa and Polyzoa of the present day.[4]

For the purpose of comparison I append a list of the leading genera of the Graptolites with the genera of Polyzoa found in the same formations.

VERTICAL RANGE OF GRAPTOLITES, ACCORDING TO NICHOLSON, LAPWORTH, AND CATALOGUE OF CAMBRIAN AND SILURIAN FOSSILS, SCHOOL OF MINES.

(L.) Lapworth. (N.) Nicholson. (S.M.C.) School of Mines Catalogue.

FORMATION.	Genera only given, with corresponding increase of Polyzoa.
Cambrian.	*Oldhamia antiqua*, Forbes; *O. radiata*, Forbes (S.M.C. p. 8).
Upper Lingula Flags.	*Dictyonema sociale*, Salter (S.M.C. p. 12), also in Tremadoc slates (N.)
Arenig and Llandeilo.	*Dichograptus*, *Didymograptus*, *Tetragraptus*, *Climacograptus*, *Diplogroptus*, *Graptolithus*, *Rastrites*, *Dictyonema?* *Phyllograptus*, *Graptolithus* (S.M.C. pp. 17-18), *Trigonograptus*, *Ptilograptus*, *Dendrograptus*, *Callograptus*, *Dictyograptus* (Lap.). POLYZOA: *Phyllopora*, *Ptilodictya* (Lower Llandeilo), Branching polyzoon (S.M.C. p. 20), hardly distinguishable in form from *Graptolithina*, only it is calcareous.
Up. Llandeilo.	*Didymograptus*, *Tetragraptus*, *Climacograptus*, *Diplograptus*, *Dicranograptus*, *Graptolithus*, *Rastrites*, *Dictyonema*, *Protovirgularia*, *Helicograptus*, *Pleurograptus*, *Dicellograptus*, *Cyrtograptus* (S.M. C. pp. 23-24). POLYZOA: *Ptilodictya* and *Fenestella?* n. sp. (Ibid. p. 28).

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[1] Geological Memoirs of North Wales, p. 328, 1866.

[2] *Ibid.*

[3] British *Graptolitidæ*, p. 85.

[4] Concluding remark in Mr. Lapworth's letter to me, May 16, 1881.

Caradoc.	*Climacograptus, Diplograptus, Dicranograptus, Dendrograptus, Graptolithus* (S.M.C. p. 31). Polyzoa: *Berenicea, Fenestella? Glauconome, Phyllopora, Ptilodictya,* great increase of species (Ibid. p. 44).
L. Llandovery.	No Graptolites in S. M. Cat., *Climacograptus* one sp., *Graptolites priodon,* Bronn (Nich. Mono. pp. 97, 98). Polyzoa: *Fenestella? Glauconome innexa, Phyllopora, Ptilodictya.*
U. Llandovery.	*Graptolithus priodon, Dictyonema* (S.M.C. p. 69). Polyzoa: *Ptilodictya, Fenestella.*
Wenlock Shale.	*Cladograptus, Cyrtograptus, Graptolithus, Retiolites, Dictyonema* (S.M.C. p. 81). Polyzoa: *Fenestella, Ptilodictya* (Stomatopora species, Vine).
Wenlock Limestone.	*Graptolithus priodon,* Bronn (S.M.C. p. 93), *Graptolites colonos, Retiolites, Cyrtograptus, Ptilograptus* (Fich. p. 98). Polyzoa: great increase of species, see list.
Lower Ludlow.	*Dendrograptus, Graptolithus* (S.M.C. p. 115). Four species recorded both in Catalogue and the same by Nicholson.
Upper Ludlow.	*Graptolithus* sp. recorded (S.M.C. p. 128).

112, Hill Top, Attercliffe, Sheffield.[1]

Errata, etc.

Page 471—3 lines from bottom remove bracket after "sub-order") and place it after "remains") in line above.

Page 473—Between "Branches," and "Gonocecium" insert—
Dissepiments. "Bars which connect together the branches."

REVIEWS.

I.—On the Organization of the Fossil Plants of the Coal-measures. Part XI. By Prof. W. C. Williamson, F.R.S. Phil. Trans. Roy. Soc., Vol. 172, Pt. 2, 1881, p. 283, and Plates 47–54.

THE contributions of Prof. Williamson to the Royal Society on the organization of the fossil plants of the Coal-measures have now reached the eleventh part, which indicates the same amount of labour and is of equal interest and importance as the preceding series. Throughout these researches the author has shown his intimate acquaintance with the views of both English and foreign writers on the subject, while his study of the recent Cryptogamia, which he has cultivated for the especial purpose of comparison, has been of material importance in these investigations, and although some few points in the structure and affinities of the fossils may be differently interpreted by other palæobotanists, the carefully executed and enlarged figures prepared by himself will be invaluable for the study of coal plants.

In the present paper the author discusses the opinion of M. Renault on the relation of *Sigillaria* and *Lepidodendron,* and after describing some new sections of these plants, Prof. Williamson considers there is "a clear proof that, contrary to the conclusions of M. Renault, age does bring about very important changes in the form and arrangement of the tissues in the branches of these plants." Further, his most recent researches have brought to light another very remarkable series of facts indicating the Lycopodiaceous

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[1] My next Report will be "Jurassic Polyzoa." Any help which can be given to me, either by the loan or "gift" of specimens; any notes of species in different localities; or help of any sort, will be duly acknowledged. I desire to make the Report as full and exact as possible.—G. R. V.

character of the Lepidodendroid and Sigillarian stems, for "whatever else may be doubtful, there is no doubt that *Stigmaria ficoides*, with its peculiar rootlets, is the root alike of *Lepidodendron* and *Sigillaria*." With regard to these rootlets, the perusal of a very important paper by M. Van Tieghem, noticing a peculiar structure of the true roots of Lycopods (Sur la symmétrie de structure des plantes vasculaires, Ann. Scien. Nat. tome 13, 1870), led Prof. Williamson to re-examine the rootlets of *Stigmaria*, and the results are described at pp. 291–294, from which it is demonstrated that "we have in each of these rootlets a single vascular bundle that commences its development eccentrically in relation to the centre of the rootlet to which it belongs, and that, proceeding from this one pole, it is developed centripetally, the extent of that development, including the number of its constituent vessels, bearing a general relation to the age of the rootlet so far as is indicated by its size. Excepting in the magnitude of the liber-cells, the resemblance to the corresponding organs in the *Selaginelleæ* is complete. Seeing that this peculiar structure only exists in the recent Lycopods and *Ophioglosseæ*, and that no other resemblance exists between the fossil *Lepidodendra* and *Sigillariæ* and the *Ophioglosseæ*, we must fall back upon the Lycopods as the plants with which this form of rootlet indicates true affinities."

In the general conclusions respecting Carboniferous Lycopods the author expresses his conviction, "that at least many of the Lepidendroid plants acquire, through advancing age, those characteristics that have hitherto been relied upon to distinguish the Sigillarian from the Lepidodendroid forms," and again, it seems to have been during the Palæozoic epoch that the great changes were effected which caused the arborescent Lycopods to be replaced by the oolitic Gymnosperms. The last section of the memoir is devoted to *Calamostachys* and *Peronosporites*. With regard to the former plant, considered to be allied to the *Equisetaceæ*, as all the examples hitherto described possessed but one kind of spore, the examination of a new specimen from the Halifax Coal-bed shows that all the sporangia of the uppermost of the three fertile verticils, as well as those to the right of the middle one, are filled with the small spores, while the three to the left of the middle verticil, and all the four of the lowermost one, contain macrospores. Prof. Williamson concludes "that this discovery of macrospores and microspores in *Calamostachys Binneyana* supplies another link connecting this strobilus with the *Lycopodiaceæ* in the same measure that it separates the fruit from the *Equisetaceæ*. That no plant belonging to the latter order ever possessed both macrospores and microspores is more than we can venture to affirm; but that no living representative of the group is known to do so is an unquestionable fact—hence to include an heterosporous *Calamostachys* in the Equisetaceous order will involve so large an alteration in the definition of the characteristics of this order as would practically involve the creation of a new one. On the other hand, this discovery strengthens my old conviction that the true affinities of this strobilus are with the *Lycopodiaceæ*. The verticillate arrangement of the fruit, and of what I believe to be the leaves (*Asterophyllites* or *Sphenophyllum*), constitute no difficulty preventing us from accepting this conclusion. Brongniart long ago pointed how commonly a verticillate foliage occurred amongst living Lycopods." Figures of this interesting form are given (pl. 54, figs. 23–27), and also of *Peronosporites*, figs. 28–38. J. M.

II.—Etna: A History of the Mountain and its Eruptions. By G. F. Rodwell. With Maps and Illustrations. (C. Kegan Paul & Co., 1881.)

THE Memoir on Mount Etna, or Monte Gibello, which Mr. Rodwell reprints from the *Encyclopædia Britannica*, contains little that is new. He refers to the writings of Lord Winchelsea, Sir William Hamilton, and Patrick Brydone, and the later works of Elie de Beaumont and of Sartorius von Waltershausen, the latter being undoubtedly the finest and most exhaustive work on the volcano. Etna is about the grandest natural object to be met with in Europe; as was pointed out by the late Prof. Jukes, we should have to put Snowdon on Ben Nevis, and Carrantuohill, the highest peak in Ireland, on the summit of both to make a mountain like Etna. There are two cities, Catania and Aci Reale, and sixty-two towns or villages on its slopes. By reason of the wonderful fertility of the soil and the healthiness of the climate, it is far more thickly populated than any other part of Sicily or Italy; more than 300,000 persons live on its sides; the population of the habitable zone of Etna amounts to 1424 per square mile. Even Lancashire, the most populous county in Great Britain (of course excepting Middlesex), and the possessor of two cities which also furnish more than a million inhabitants, has a population of only 1479 to the square mile. The minor craters round the centre cone are to be counted by hundreds. The account of the ascent, and the stay on the way at the Casa Inglesi, is much like that which we have all read in daily papers or weekly journals. The summit was reached just before sunrise, and Mr. Rodwell had the good fortune to see the projection of the triangular shadow of the mountain across the island, a hundred miles away. The shadow appeared vertically suspended in space at or beyond Palermo, and resting on a slightly misty atmosphere; it gradually sank until it reached the surface of the island, and as the sun rose it approached nearer and nearer to the base of the mountain. The more purely scientific part of this memoir does not appear to be strong; "hydrochloric acid," he writes, "is said to frequently issue from the crater." The snow which falls on the mountain is stowed away in caves and used by the Sicilians during summer. A ship load is also sent to Malta, and the Archbishop of Catania derives a good deal of his income from the sale of Etna snow. During the descent the apparent nearness of the minor cones and of the villages at the base of the mountain strikes the observer. They appear to be painted on a vertical wall, and although from ten to fifteen miles distant, seem to be almost within a stone's throw. This is the effect of refraction, for at the summit we leave one-third of the atmosphere beneath us, and in looking towards the base we are looking from a rarer to a denser medium. In a chapter he gives an account of seventy-eight eruptions of the volcano. The coloured map of Etna is curious in that the beds of modern lava bear the closest resemblance to stag's horn moss. Mr. Rutley discourses on the microscopic characters of the sections of the lavas, and speaks of "a slight residuum of glass," "some interstitial glass," "a small quantity of interstitial glass." Would it not be well to let the reader know what is meant by the very technical use of this word "glass"?

III.—GEOLOGICAL SKETCH OF THE NORTH OF FRANCE AND THE ADJACENT DISTRICTS.

ESQUISSE GÉOLOGIQUE DU NORD DE LA FRANCE ET DES CONTRÉES VOISINES. Par M. J. GOSSELET, Professeur à la Faculté des Sciences de Lille. 2e Fascicule, Terrains Secondaires. (Lille, 1881.)

AMONG his numerous contributions to geological science, Prof. J. Gosselet has prepared a geological sketch of the Department of the North and adjacent districts, of which two parts have appeared. A work by him under a similar title, but on a smaller scale, and without illustrations, was published about five years ago.

The first part of the enlarged edition comprises the Palæozoic rocks, the present part is devoted to the "Terrains Secondaires," including the Triassic, Jurassic, and Cretaceous series of the northern region of France. The palæontological, mineralogical, and stratigraphical characters of each great division, and their geographical distribution, are given, followed by a concise description of the subdivisions of each group, with lists of the most characteristic fossils, and useful synoptical tables of the Jurassic and Cretaceous strata. This second fasciculus is accompanied by an atlas containing thirteen carefully executed plates of the more characteristic fossils of each subdivision from the Hettangien to the Turonien, four double plates showing the area of the continental land, and of the sea deposits of the Jurassic, Albien, Cenomanien, Turonien, and Senonien epochs, as well as six double plates illustrating fifty-five of the more important geological sections and superposition of the strata in the country. This work when completed will form a useful *résumé* to those interested in the leading geological features of the northern district of France, or in comparing them with the synchronous deposits of our own country.

For the "Esquisse Géologique" and other memoirs bearing on the geological constitution of the Ardennes, the Academy of Sciences of Paris this year awarded the Bourdin prize,—a worthy recognition of the conscientious labours of Prof. J. Gosselet for many years on the geology of his Department (du Nord) and the adjacent country.

J. M.

CORRESPONDENCE.

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THE "LOWER KEUPER SANDSTONE" OR "BASEMENT BEDS."

Sir,—While cordially agreeing with much that Mr. Strahan has to say on the above subject, I would enter a strong protest against the general line of argument which runs through his paper to the effect that, in the Midland counties, the Basement Beds of the Keuper are more closely connected stratigraphically as well as lithologically with the underlying Bunter sandstone than with the overlying members of the Keuper, and that the most important break in the Triassic series comes at the base, not of the Basement Beds of the Keuper, but of the Waterstones. In the counties of Nottingham, Derby, and Stafford, the Keuper Basement Beds consist of a series of white and red sandstones and conglomerates with irregular interstratifications of red marl; they are very variable in character and thickness, never more than 50 or 60 feet, and often entirely absent. On the east side of Nottingham the Keuper Basement Beds (when present) rest on the Pebble Beds of the Bunter; but four miles west of the town, in Stapleford Hill (where by the way they are locally well developed), and in Catstone Hill, they repose directly on the Lower Mottled Sandstone of the Bunter. Here then we get decisive evidence of an unconformable overlap of the Bunter Pebble Beds by the Keuper Basement Beds, and the removal of at least 200 feet of strata during the interval of time which separated those two groups of rocks.

Mr. Strahan cites the appearances of erosion of the Basement Beds beneath the Waterstones in support of his theory of a great break at that horizon, but denies that erosion of the rocks beneath the Basement Beds is of any value as evidence of a break between the Basement Beds and the Bunter. About three years ago I had the opportunity of examining the junction of the Keuper Basement Beds and Waterstones, at Colwick Wood near Nottingham, for a distance of over a hundred yards. In this section the (irregular) bedding planes of the Basement Beds ran roughly parallel with those of the Waterstones. At the top, though the junction line was quite even, the Basement Beds certainly had the appearance of having suffered denudation before the deposition of the Waterstones. In view however of the abundant evidences of contemporaneous erosion in the Basement Beds, no importance can be attached to these appearances as indicative of any considerable lapse of time between the two series. The Waterstones and the Basement Beds were apparently conformable. This conformability is equally evident in the district of Alton, Staffordshire.

It is true that, in parts of Notts and Derbyshire, the upper members of the Keuper overlap the Keuper Basement Beds and rest on the Bunter and older rocks, but we have good reason for believing that this is simply a *conformable* overlap, for the Waterstones are themselves also partially or wholly cut out by the rising surface of the older underlying rocks.

At the close of the Bunter period, elevation took place, in the Midlands certainly, if not generally throughout the country, accompanied by extensive and long-continued denudation: during this interval of time the land appears to have been cut up by subaërial erosion, and its surface furrowed by channels.

On depression again setting in at the commencement of the Keuper period, these hollows appear to have been first filled up by coarse sediments that were drifted along by powerful westerly currents. This will suffice to explain the local development and rapid fluctuations in thickness of the Keuper Basement Beds.

In lithological character the Keuper Basement Beds show marked differences both from the underlying Bunter Sandstones and the overlying Waterstones; though there are beds in the series which strongly resemble one or other of those rocks. *Typically*, however, the texture of the Basement Beds is essentially Keuper-like: the grains of sand, whether coarse as any Bunter or fine as any Keuper sandstone, are mostly angular, clean, and of a flat and elongated or schistose type, while those of the Bunter are of a more globular or granitic type, and generally stained with a coating of ferric oxide; mica too is much more abundant than in most Bunter Sandstones. The quartzites of the Keuper Basement Beds count for less than nothing, as they have all the appearance of having been derived from the waste of the Bunter Pebble Beds.

I quite agree with Mr. Strahan that the Keuper Basement Beds, as defined by him, form a distinct subdivision of the Triassic series, and that whilst the Waterstones graduate up into the Red Marls, and their division therefrom is arbitrary, the Basement Beds are sharply separated from the rest of the Keuper.

In conclusion, I would recommend the retention of the term "Basement Beds" applied to these rocks as more expressive and less open to misinterpretation than that horribly confusing phrase "Lower Keuper Sandstone." E. Wilson.

Nottingham, 5 *Oct.* 1881.

MR. FISHER'S REPLY TO MR. DAY'S CRITICISM.

Sir,—If Mr. Day will consider what I meant by "obliquity of trend," in the trace of a furrow, made by a railway cutting, he will perceive that my assertion is correct, that "no apparent obliquity of trend can be given by a vertical section, *e.g.* by a vertical cliff." I believe that the difference between us arises from our understanding the obliquity to apply to different angles.[1]

To use Mr. Day's illustration of a shadow: let the shadow, made by horizontal rays, of a vertical square, whose sides are vertical and horizontal, fall upon a plane which is not parallel to the plane of the square. So long as the plane which receives the shadow is vertical (which answers to the vertical cliff), the shadow of a vertical edge of the square will be perpendicular to a horizontal line drawn on the plane. But if the plane be inclined to the horizon, the shadow of the vertical edge of the square will no longer be perpendicular to the horizontal line. It is the angle between the shadow of the edge

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[1] See Mr. Fisher's article, January, 1881, p. 20.

and a perpendicular to the horizontal line, which measures the "obliquity of trend," caused, as it will be observed, by the shadow-receiving plane being inclined to the horizon. If the plane be vertical, there will be no such obliquity.

O. Fisher.

RATE OF DENUDATION OF THE LAND BY RIVERS.

Sir,—In a paper published in April, 1853, in the Phil. Mag. I have calculated the mean denudation of the land by rivers and the sea to be equal to three feet in 10,000 years, taken over the whole surface of the land. I further corrected this in 1875, Appendix Geol. Mag. p. 433, *et seq.*, by taking into account the quantity of material not in suspension, viz. sand, etc., pushed out to sea by rivers. I find this equal to twice as much denudation as the material carried out to sea in suspension indicated by a new method.

I omitted this point in 1853, and Mr. James Croll, who followed my method of calculations, has always omitted it also.

This denudation would be nearly ten feet in 10,000 years, or one foot in 1000 years, with the present rainfall. But in the Pluvial period the rainfall would be 300 inches, or about ten times as great as the present. Belgrand afterwards suggested a twenty-fold rainfall.

By my formula of the increase of velocity of water at the same slope, according to increase of quantity, I found the velocity of streams would be enormously increased in the Pluvial period, particularly in the rainy seasons, as the quantity flowing in rivers would be enormous. If the quantity of rain increased eight times, the velocity of the stream would be double; but if the rainfall was very unequal, the mean velocity for the year might be much in excess, say three times the present velocity. In the Pluvial period, if the mean velocity may have been three times the present mean velocity of streams and rivers, Hopkins has shown the power of moving material increases in an enormous ratio with the velocity. If the moving force for removing strata is as the fifth power, and the velocity 3 times, then as 3^5 equals 729, the mean denudation in the Pluvial period would be 729 times the present. This would be equal to a mean removal of 9 inches in the year off the land, and a mean deposit of 3 inches in the sea, raising the sea-level to that extent.

The deltas of all great modern rivers are formed of thin stratified beds containing land plants, and always recent fresh-water shells that can only live in shallow fresh-water, or shells or animals living in estuaries. The surface of these modern deltas is always near the level of the sea at the shore-line, and must have always been so during their formation, as they are all shallow-water deposits. As the sea-level rose during the supposed period of 729 years, the deposits must all that time have exactly kept up with the elevation in order to keep marine deposits away. The depth of these delta deposits is from 500 to 1000 feet, as ascertained by borings.

In 3000 years, with a mean denudation of land of 9 inches a year, and an annual rise of the sea of 3 inches of sea-level, a delta of 729 feet could have been formed by the deposits obtained by the overflow of the river-water, with the assistance of some material thrown back by the sea into the estuary or delta.

The deltas of all our great rivers are thus later than Post-Pliocene, and of the age of the Pluvial period. No part of any of these deltas has been uplifted by volcanic or subterranean agency above the general level of the delta; this is another proof of recent origin.

Alfred Tylor.

ROCK-BASINS IN GRANITE.

Sir,—In reply to the query of Mr. T. Cragor in your last number, I would refer him to a paper "On the Rock-Basins in the Granite of the Dartmoor District, Devonshire," by G. W. Ormerod (Quart. Journ. Geol. Soc. vol. xv. p. 16). In this paper the author brings forward reasons for considering that the Rock-basins were formed by atmospheric action, which commenced in irregularities on the surface of the granite and was probably assisted by a globular or spheroidal structure in the rock. H. B. W.

JOINT-STRUCTURE AT GREAT DEPTHS.

Sir,—Mr. Crosby (Geol. Mag. Sept. 1881, p. 416) explains the absence of joint-structure at great depths by attributing the formation of these divisional planes to the cooling of strata from a temperature which prevented them from becoming jointed by contraction before they were thoroughly desiccated and consolidated. This appears to me to explain what occurs in jointed conglomerates, in which hard quartz and other pebbles are often "cut through by joints, as neatly as if they had been sliced by a lapidary's wheel." But, if this is the cause of jointing, why have we joint planes continuous in direction over wide areas, cutting rocks up into cuboidal or polygonal masses, and not division along planes of least resistance, such as would form the prisms so familiar in rocks which have cooled from fusion or from a high temperature like the columnar mud of Tideswell dale.

The conditions suggested by Mr. Crosby appear to me to be such as would produce columnar jointing, viz. slow, regular contraction in a more or less homogeneous rock; why then is not the jointing of this nature? Seeking purely for information on this head, I am yours, &c., W. W. Watts.

Sidney College, Cambridge,
October 11*th*, 1881.

DISCOVERY OF COAL-MEASURES UNDER NEW RED SANDSTONE AND ON SO-CALLED PERMIAN ROCKS AT ST. HELEN'S, LANCASHIRE.

Sir,—Permit me to point out that the author of this paper in the current number of the Geological Magazine, in identifying the limestone bands met with beneath the New Red Sandstone at Winwick in 1879, with the Ardwick Limestones of the Manchester Coal-field, does not state that this identification was made by me in May of that year, when Mr. A. Timmins, Stud. Inst. C.E., kindly showed me the series of specimens, at Runcorn. Mr. A. Timmins had himself recognized the fact that the beds in question were *limestones*, and had, in fact, made a rough analysis of them, which I urged him to send to the Manchester Geological Society, with a note from myself as to their geological identification, which I at once recognized—having shortly before, through the courtesy of Mr. Vivian, of the North England Rock Boring Company, examined the fine series of cores obtained at Clayton Vale, east of Manchester, where the *Ardwick Series* was penetrated. In the fifth report of the Underground Water Committee of the British Association, read at Sheffield in August, 1879, and printed in the volume for that year, I alluded to my identification, and in June, 1880, I published the detailed section of the Winwick boring, drawn up from my notes of the samples, in my paper published in the Manchester Geological Society's Transactions, on "Further Notes on Triassic Borings near Warrington." From which, perhaps, I may be permitted to quote the following passages. "These Coal-measure deposits occurring at a depth of only 340 feet or 113 yards from the surface, cannot be regarded as a discovery of the highest commercial interest, for looking to the westerly attenuation of thickness of the Coal-measures of South Lancashire, to which I have already drawn the attention of the Society, there can be little doubt but that the Manchester Coal-field will occur at a less depth beneath the limestone than at Manchester, in which case a valuable and workable Coal-field may be under the London and North Western Railway at Parkside, where a boring has recently been carried out," . . . . and, "should the limestones of Winwick belong to the same horizon as those of the Manchester Coal-field, it is in the highest degree probable that another 600 feet, and possibly much less, would reach the Openshaw Coal, or its equivalents."

H. M. Geol. Survey,
54, West Parade, Rhyl.

Chas. De Rance, F.G.S.,
Assoc. Inst. C.E.

MR. H. H. HOWORTH ON THE SUDDEN EXTINCTION OF THE MAMMOTH.

Sir,—As one of a numerous body of students of that most fascinating science Geology, I venture to address you a few lines to ask you to use your influence to induce writers, at least in your own Magazine, to make use of their own language in their scientific papers, and so to largely to increase the number of their readers. In your September Number is a paper on a subject in which I—and many other equally unlearned students of nature—take much interest. From the cause above named, all who are not thoroughly versed in both Latin and German are bound to take on trust evidence that is quoted in support of the theory brought forward, which evidence, had it been given in English, would have considerably increased the interest in the paper of myself and many other of your readers. Why should Englishmen, more than any other men, err in this way? We have a language much more expressive than either Latin, French, or German, yet some of our *learned* countrymen seem to delight in writing their scientific papers in one of those foreign languages. In most foreign works, I think you will find quotations translated into the language of the country; why not in ours? Ignoramus.

Bristol, *Oct.*, 1881.

MISCELLANEOUS.

The Blackheath Subsidences.—The Report of the Committee for the exploration of these subsidences has just been published by the Lewisham and Blackheath Scientific Association. Unfortunately they have been unable to arrive at any positive solution of the problem which lay before them; but Mr. T. V. Holmes, F.G.S., has appended some observations, accompanied by a plan and sections, which acquaint us with all the facts of the case, and render most plausible his view that the plateau of Blackheath was chosen for the site of Dane's Holes, of which the holes recently exposed are examples. (See Geol. Mag. for July, 1881, p. 336.)

Postscript to Note on a New English *Homalonotus* from the Devonian, Torquay, S. Devon (see p. 489).—Since the foregoing was written I have been favoured by Mr. Champernowne with a series of specimens obtained by him from the same locality as yielded the *Homalonotus Champernownei*, described above. These have been carefully examined by my colleague, Mr. R. Etheridge, F.R.S., who has determined them thus:—

Rhynchonella Pengellyana?
Streptorhynchus umbraculum.
Spirifera cultrijugata.
Chonetes, sp.
Orthis, sp.
Pullastra, sp.
Holopella, sp., or *Loxonema*, sp.
(and one or two other indeterminate Gasteropoda.)
Cyrtoceras, sp.
Orthoceras, sp.
Pleurodictyum problematicum.
Petraia, sp.

There are also several parts of *Homalonotus*, probably representing two other species, and a caudal portion which may have belonged to *H. Champernownei*, H. Woodw.—H.W.

Mr. R. Etheridge, F.R.S., President Geol. Soc. London, who has so ably filled the post of Palæontologist to H.M. Geological Survey in the Museum of Practical Geology, Jermyn Street, for the past twenty-four years, has just accepted the office of Assistant-Keeper to the Department of Geology in the British Museum (Natural History), S.W., where he will in future be associated with Dr. H. Woodward, F.R.S. Mr. Etheridge's eminent services in Geology and Palæontology, and his long connection with this Magazine, as one of its Editors, have rendered his name widely known to the scientific world. All who know Mr. Etheridge will rejoice at any advancement which will afford him more leisure for the pursuit of his palæontological studies, and will join us in expressing the hope that he may long be spared to enjoy his present position. Mr. Etheridge's address will in future be: "British Museum (Natural History), Cromwell Road, South Kensington, S.W."


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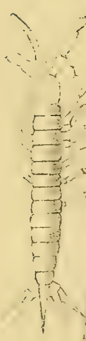
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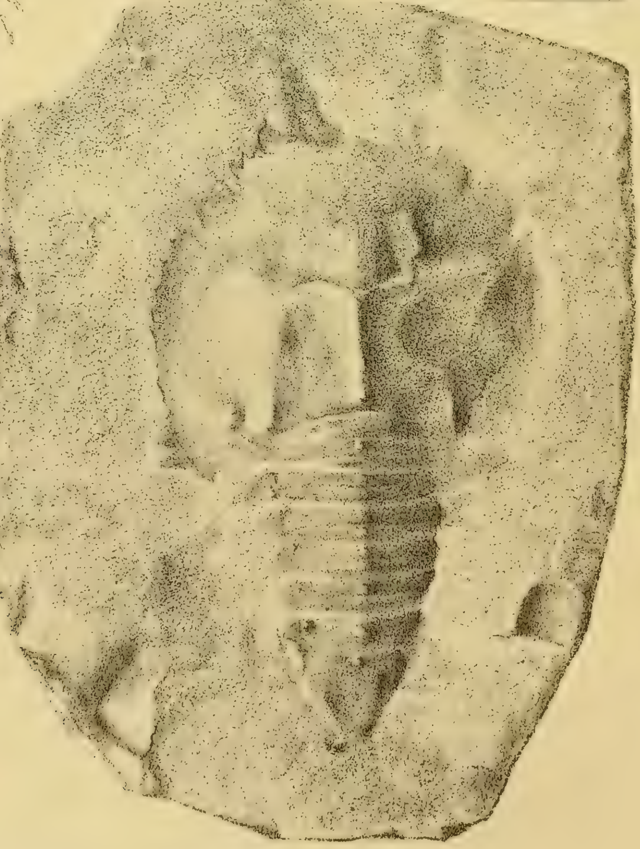
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G. M. Woodward del. et lith.

West Newman & Co. imp.

New British & Foreign Crustacea.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VIII.

No. XII.—DECEMBER, 1881.

ORIGINAL ARTICLES.

◆

I.—CONTRIBUTIONS TO THE STUDY OF FOSSIL CRUSTACEA.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S.

(PLATE XIV.)

HAVING received an invitation from Mr. W. Stoddart to examine the collection of his late father, Mr. W. W. Stoddart, F.G.S., at Sneyd Park, Clifton, Bristol, I availed myself of the opportunity to do so in April last, and was interested in finding, among many other good British fossils, a new and undescribed Crustacean belonging to the genus *Eryon*, from the Stonesfield Slate of Stonesfield, Oxfordshire.

Unfortunately only the intaglio is preserved, the relievo side having probably escaped detection or been broken up. This is, however, sufficiently clear to enable one readily to compare it with the other known forms of this well-marked genus.

Ten species of *Eryon* have been described from the Lithographic Stone of Solenhofen, which may be considered as probably near the horizon of our Kimmeridge Clay. They are:—

Eryon propinquus, Schlot.
,, *spinimanus*, Germ.
,, *orbiculatus*, Münst.
,, *elongatus*, Münst.
,, *arctiformis*, Schlot.
Eryon bilobatus, Münst.
,, *longipes*, Fraas.
,, *Schuberti*, Meyer.
,, *Redenbacheri*, Münst.
,, *Oppeli*, H. Woodw.

To these must be added one species from the Oxford Clay of the Haute-Saône, France, viz:—

Eryon Perroni, Etallon.

Next in descending order will come Mr. Stoddart's *Eryon* from the Stonesfield Slate.

1.—*Eryon Stoddarti*, H. Woodw., sp. nov. Plate XIV. Fig. 2.

Description.—Carapace one-third broader than long, cervical groove moderately deep and well defined; dorsal ridge strongly marked and extending from the posterior border to the cervical groove; two equidistant branchio-cardiac ridges extend from the same groove to the posterior border on either side, terminating just where the margin of the first abdominal segment joins the carapace; the cervical groove is marked by a deep notch on the border of the carapace, and the posterior edge of the notch is sharply toothed; the branchial border is evenly rounded, and bears several small denticles upon it; the hepatic region has two strongly-marked rounded notches, and the border is also finely dentated; the anterior border is not clearly defined. Greatest breadth of carapace, 5 centimètres; length, 3½ centimètres. Length of abdomen, including telson, 4½ centimètres; greatest breadth, 2½ centimètres.

The first abdominal somite is narrow, and has a straight groove running across it; the mesial line is marked by a single tubercle. The three following somites are also transversely grooved and have two tubercles on the mesial line, one on either side of the groove; the epimeral pieces are small and somewhat acuminate; the border of each somite is marked by a rounded tubercle at its union with the succeeding somite. The last two somites have only one central tubercle, but are transversely grooved like the preceding. The seventh somite or "telson" is nearly triangular in form, and is marked by two converging ridges, and ends in a terminal spine. The broad lateral swimming-plates are not preserved.

This new species of *Eryon* serves as a link between the Lithographic and Oxfordian *Eryons* above mentioned and those from the Lias below, namely:—

From the UPPER LIAS.

Eryon Hartmanni, Meyer, U. Lias, Würtemberg.
,, *Edwardsii*, Morière, U. Lias, Calvados.
,, *Moorei*, H. Woodw., U. Lias, Ilminster.

And from the LOWER LIAS.

Eryon Escheri, Oppel, L. Lias, Baden.
,, *antiquus*, Brodp., L. Lias, Lyme Regis.
,, *Barroviensis*, M'Coy, L. Lias, Barrow-on-Soar, etc.
,, *Wilmcotensis*, H. Woodw., L. Lias, Wilmcote.
,, *Brodiei*, H. Woodw., L. Lias, Lyme Regis.
,, *crassichelis*, H. Woodw., L. Lias, Lyme Regis.

It will be seen at a glance that the 20 species we have enumerated are nearly equally divided between the Upper Oolite (Kimmeridgian) and the Lias; only one form, *Eryon Perroni*, Etallon, being found in the Oxford Clay of Calmoutiers, Haute-Saône.

Eryon Stoddarti most nearly approaches the Liassic species, in which the cervical groove is always strongly marked, and also the dorsal and branchio-cardiac ridges, characters not so strongly defined and often absent in the species from Solenhofen.

2.—*Eryon Neocomiensis*, Hohenegger (MS.). Pl. XIV. Fig. 1.

That distinguished palæontologist, the late Dr. Albert Oppel, in his well-known "Palæontologische Mittheilungen" (Stuttgart, 1862), p. 9, observes on the geological distribution of the genus *Eryon*, "that one finds this genus in the various strata from the Lowest Lias to the Upper Jurassic beds; we may therefore conclude that it enjoyed an unbroken existence through the whole Jurassic period. And further, the Jurassic species of *Eryon* were preceded by the still earlier *Eryon* (*Bolina*) *Raiblanus*, Bronn, sp., from the Trias of Raibl, Bohemia; and the *Eryon* (*Tropifer*) *lævis*, Gould, sp., from the Rhætic Bone-bed of Aust-passage, a doubtful species at best. This genus then may be said to have its beginning in the Trias, and to have continued through the entire Jurassic period, and as far upwards as the Chalk, where it becomes extinct."

Dr. Oppel cites as his authority for the occurrence of *Eryon* in the Chalk, "The Geology of the South-east of England," by G. A. Mantell, p. 373,[1] (1833), 8vo.

On referring to Mantell's work, we find a list of fossils given and the genus *Eryon* quoted; with a foot-note stating that the specimen was "too imperfect for the species to be ascertained." As no figure is given, nor does any Cretaceous *Eryon* exist among the Mantellian Collection preserved in our National Museum, we may, I think, justly conclude that the reference made by Dr. Mantell to *Eryon* as occurring in the Chalk was erroneous.

Although the specimen cited by the late Dr. Oppel failed to establish the existence of the genus *Eryon* in the English Chalk, I have been fortunate in fixing the presence of this genus in the Neocomian of Silesia.

When visiting the magnificent palæontological collections preserved in the Royal Bavarian Museum in Münich, in 1876, under the direction of Dr. Oppel's eminent successor, Professor Dr. Karl Zittel, I observed a most interesting and perfect example of *Eryon* from the Lowest Cretaceous (Neocomian) of the North Carpathians of Silesia, which by the kindness of Dr. Zittel I was permitted to study and describe.

The fossil, which is preserved as an impression and counterpart in two small blocks of hard black bituminous-looking limestone, exhibits an entire Crustacean measuring nearly 35 millimètres in length, and 22 millimètres in breadth, having the carapace, all the segments of the body, with the "telson," or tail-spine, the broad natatory caudal appendages, and the great chelate fore-limbs united together as in life.

This specimen was obtained in Feb., 1863, by Dr. L. Hohenegger, the late Director of the Arch-Ducal Iron-works in Silesia, Galicia and Hungary, from the Neocomian of Niederlishna, Silesia, and named by him in MS. *Eryon Neocomiensis.*

In describing the Lower Neocomian of this district [see Geognostic Sketch of the North Carpathians of Silesia and the adjacent district, brought up to the present state of our knowledge, by L. Hohenegger (Jahrbuch der k. k. Geologischen Reichsanstalt, Band 3, 1852, Wien, Royal 8vo. pp. 135–148, Taf. I.)], Dr. Hohenegger writes:—

"The identity of the small but numerous patches of 'Coral Limestone' in this district, with the Limestone of Stramberg, near Neutitschein, is now established beyond a doubt, by means of the fossils which have been obtained. They may be correlated with the Ignazi and Horki Mountains in Moravia and Tichau, Chlebowitz, etc., in Neutitschein.

"Although the fauna of this place does not everywhere show exactly the same facies, nevertheless it embraces the characteristic bivalves which place its identity beyond all doubt. Besides which, these 'Coral Limestones' all resemble one another both in their mechanical and chemical constitution, although they vary from the purest white to blackish-grey in colour: which latter tint" [as well

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[1] The other references given by Dr. Oppel, viz. to Meyer in Nova Acta Leopold. Carol. Acad. p. 283, and to Morris, Cat. Brit. Fos. 1854, p. 108, are but the repetition of the same reference to Mantell.

seen in the matrix of the fossil *Eryon* about to be described] "is caused by its being strongly impregnated with bitumen, and is very prominent in the 'Coral Limestone' of Bobrek."

Eryon Neocomiensis, sp. nov. Pl. XIV. Fig. 1.

Description.—The contour of the carapace is nearly circular, being wider in front than behind: the anterior border is indented near the attachment for the antennæ and the eye-stalks; the hepatic border has a small and straight notch, and the cervical furrow is also marked by a similar rounded indentation in the lateral margins; the posterior border of the carapace is roundly indented; the first abdominal segment exactly occupying the concavity.

The carapace appears to have been extremely thin and delicate in texture; it is divided by a mesial ridge running from the posterior to the anterior margin, and by a branchio-cardiac ridge on either side the mesial one.

The abdominal segments (with the exception of the first) are nearly uniform in size, and each has an elongated ridge down the centre; the lateral portion of each segment being slightly granular, and the border rounded. They decrease from the second to the sixth, from 7 mm. to 5 mm. in breadth. The telson, which is hastate in form, is 6 mm. long or one-fifth the entire length of the whole specimen; the telson and the swimmerets of the tail together are 12 mm. in breadth. The large claws are well preserved; the hand measuring 6 mm., and to the extremity of the pincers 11 mm. The chelæ are long, slender, and recurved, very much resembling species of *Eryon* from Solenhofen. The wrist is only 2 mm. long, the arm may be estimated at 11 mm.

The eyes are, if present, indistinct; but the large rounded scale at the base of the outer antenna can be distinctly seen and the antennæ and antennules can also be made out in a good light with a pocket lens. The three basal joints of the antennæ are stout, the first two are oblong in form, and the third joint has the inner angle produced. The total length, to the end of the flagellum, is about 8 mm. The antennules are slender and bifid, and measure 5 mm. in total length.

Mr. H. N. Moseley, F.R.S., Naturalist on board the "Challenger," mentions that "in dredging off Matuku Island, in 320 fathoms, on a coral bottom, some *Phorus*, *Turritellæ*, and a few other shells were brought up, *as well as numerous specimens of the blind Crustacean Polycheles*, and other animals, showing the fauna to be a true deep-water one, and with these a living specimen of the Pearly Nautilus." The same Crustacean (*Polycheles*), he states, was dredged off the Island of Sombrero in the Danish West Indies, in from 450 to 490 fathoms.

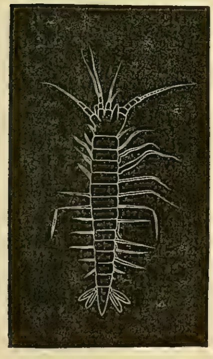
There can be very little doubt that this curious Crustacean (*Polycheles*), like the Pearly Nautilus with which it was dredged up from these great depths, is the modern representative of this ancient genus *Eryon*, and that its range in time was probably nearly coequal with that of the *Nautilus*.

Like its living congener (*Polycheles*) and its fossil predecessor in the Lithographic Limestone of Solenhofen, this new Cretaceous *Eryon* from Niederlishna has the outer caudal plates of the tail entire, whereas in the older Liassic form of *Eryon* it is divided across by a transverse joint, as is also the case in the outer swimmeret of the tail of *Astacus, Homarus, Nephrops*, and many other genera. This genus is remarkable for the persistent character of its hastiform telson, observable not only in the living genus *Polycheles*, but also in its Liassic predecessor, *Eryon Barroviensis. Eryon Oppeli* is the only species with an ovately rounded telson; and therefore probably indicates it to belong to another genus.

3.—*Palæocaris Burnettii*, H. Woodw., sp. nov. Pl. XIV. Fig. 3*a*, *b*.

The genus *Palæocaris* was proposed by Messrs. Meek and Worthen, in the Proceedings of the Academy of Natural Sciences, Philadelphia, in March, 1865, p. 48, for a remarkable type of Crustacean obtained from near the base of the Coal-measures of Morris, Grundy County, Illinois, U.S.A., having the "inner and outer pairs of antennæ of nearly equal length, the former each bearing a well-developed accessory appendage; the peduncles of both pairs being shorter than the flagella. Head about as long as the first two abdominal segments. Thoracic legs long and slender; anterior pair not chelate. Telson long, tapering and horizontally flattened; 'stylets' with first joint very small, second double, and also flattened horizontally."

Only one species, *Palæocaris typus*, has been defined by Messrs. Meek and Worthen. The authors describe the "thorax" as "*slightly wider* near the middle than the abdomen"; and the "thoracic and abdominal segments of nearly equal length"; the "telson nearly as broad at the base as the penultimate segment, tapering, and as long as two and a half of the abdominal segments. The 'stylets' (or lateral caudal appendages, sometimes called 'swimmerets') with the first joint very minute, second joint with each division as long as the telson, and lanceolinear in form, with pointed extremities and parallel setigerous margins."


Palæocaris typus, Meek & Worthen.

This curious larval-looking genus of Crustaceans and another genus found by these authors in the same locality and formation, which closely resembles it, named by them, *Acanthotelson Stimpsoni* (see our Plate XIV. Fig. 4) have been referred by Prof. J. D. Dana, "to a group probably holding an intermediate position between the typical Isopoda and the Amphipoda for which he proposed the name Anisopoda."

"This intermediate group, as first shown by Prof. Dana, is characterized, like the Amphipoda, by having the three posterior pairs of thoracic legs in one series, and the four anterior pairs in another; while, as in the Isopoda, the branchiæ are abdominal, and only one pair of abdominal appendages are styliform and five are branchial."

Such characters as the above, however applicable to *recent* forms, "cannot," as Messrs. Meek and Worthen well observe, "be often made available for the investigation of crushed *fossil* species where so many accidents might have occurred," to disarrange the natural order of the appendages.

Having been favoured by Mr. Robert F. Burnett, F.G.S., of Manchester, with the loan of a specimen, obtained by him in May, 1879, from the Middle Coal-Measures, River Section, Irwell Valley, which evidently belongs to the genus *Palæocaris*, I think it sufficiently interesting to bring it under the notice of the readers of the Geological Magazine, being its first occurrence in England.

The specimen from Manchester exhibits the dorsal aspect of an individual about 30 millimètres in length, and 3 mm. in breadth; composed of a head, rounded in front, about 3 mm. in length; the somites, of which there are fourteen, each measuring about 2 mm. in length; the telson or tail-spine which is linear-lanceolate in form, is 5 mm. long, and the swimmerets are of equal length and striated longitudinally. Each somite has from 8 to 10 parallel striæ crossing it from side to side. The last 7 (abdominal) somites have a tendency to diminish slightly in succession from before backwards, and have the angles of the posterior border of each segment slightly produced.

Two small rounded scales (which *may be eyes*, but certainly have not the structure of eyes preserved), one being much more distinctly evident than the other, are attached on either side, near the front of the head.

Save these cephalic appendages (which do not seem to correspond with any appendage on the head of Messrs. Meek and Worthen's figures of *Palæocaris typus*, see woodcut), there are no other organs attached to the body except the telson, and the lateral lobes of the tail-fin.

The well-marked transverse striæ of the body-segments, their nearly uniform breadth anteriorly, and the more marked tendency of the abdominal rings to have their posterior border produced, with their pleuræ slightly prominent, together with the more narrow form of the head, with its rounded scales, or *eyes?* (reminding one casually of the head of *Prosoponiscus problematicus* from the Permian of Durham), sufficiently entitle this form to be treated as specifically distinct, and we therefore have much pleasure in dedicating it to the discoverer, in whose collection the specimen is preserved.

EXPLANATION OF PLATE XIV.

Fig. 1. *Eryon Neocomiensis*, sp. nov. Lowest Cretaceous (Neocomian), Niederlishna, Silesia. Royal Bavarian Museum, Munich.

,, 2. *Eryon Stoddarti*, sp. nov. Stonesfield Slate (Great Oolite), Stonesfield, Oxfordshire. Coll. of the late Mr. W. W. Stoddart, Clifton, Bristol.

,, 3. *Palæocaris Burnetti*, sp. nov. Middle Coal-measures, River Section, Irwell Valley. Collection of R. F. Burnett, Esq., F.G.S., Manchester.

,, 4. *Acanthotelson Stimpsoni*, Meek and Worthen, Coal-measures, Morris, Grundy Co., Illinois.

II.—On the Bridlington and Dimlington Glacial Shell-beds.

By G. W. Lamplugh.

(PLATE VIII. p. 537.)

A paper read before the British Association at York, Sept. 1881.

THE wooden defences which protected the cliff opposite the Alexandra Hotel at Bridlington Quay having been removed last autumn, preparatory to the erection of a more substantial concrete wall, a section was, for a short time, exposed which had long been hidden (see section Pl. VIII. p. 537). The length of this section was a little over 1,000 feet, extending from Sands Cut to Carr Lane; its average height was about 30 feet.

For the northern two-thirds of its length, this section showed Purple Boulder-clay (No. 3 of section) overlaid by chalky gravel (No. 2); and above the gravel a shelly fresh-water marl, apparently quite recent (No. 1). The Boulder-clay and gravel were very curiously intermingled, detached masses and long tapering tongues of clay (in many places showing slickensides) extending far into the crushed and contorted gravels.

In this part of the section, it seemed to me that two gravels of different ages, the uppermost, probably of fresh-water origin, were mingled with the remains of a once-dividing clay-band; for, in the cliff two hundred yards further north, a thin Boulder-clay, much torn and dragged in its upper part, and in one or two places quite cut through, is still seen between two similar gravels.[1] But, as drainage works, which will doubtless yield fresh evidence, are now being carried on in the town, I will reserve, for the present, any further account of these beds.[2]

Below the Purple Clay in the southern third of the section, about twelve feet of a Lower Boulder-clay was seen (No. 4), which corresponded to the "Basement Clay" of Messrs. Wood and Rome.[3] This clay, which was very distinct from the Purple Clay in colour and character, was of a hard sandy nature and dark greenish-blue colour. Boulders were neither plentiful nor large in it, but the majority were far-travelled. Carboniferous rocks and Whin were far rarer than in the Purple Clay, whilst in their place were a great variety of igneous and metamorphic rocks—all quite unknown to me—with many black flints which do not seen to have come from any chalk now seen in Yorkshire. A few of these flints were green-coated.

If Scandinavian or other foreign rocks be sought for in East Yorkshire, I think the exposures of this clay on the beach either at Bridlington or Dimlington form by far the most promising grounds for exploration.

This Boulder-clay also contained several masses of included material differing from itself; and in these included masses were many shells, both broken and unbroken, of species which showed

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[1] For a section of this part of the cliff, showing the two gravels, see Geol. Mag. Sept. 1879, p. 393.

[2] For later account of these beds see forthcoming Proc. Yorkshire Geol. Soc. 1881.

[3] Quart. Journ. Geol. Soc. vol. xxiv. p. 147.

them to be closely related to the well-known shell-bed, from which many years ago so many glacial shells were obtained, and which has long been hidden behind a sea-defence a short distance southward. This deposit, which was called by its discoverers the "Bridlington Crag," has always been of great interest to glacialists, but seems to have been the subject of much misconception; and the object of this paper is, by re-examining the old evidence, and bringing forward new, to render our knowledge of the bed more complete.

THE BRIDLINGTON CRAG.—When we examine the published descriptions of this shell-bed, we find they differ in several important particulars.

Its discoverer in 1835, Mr. W. Bean, describes it[1] as "a deposit of *fragile and broken shells*[2] . . . . a heterogeneous mass, only a few yards long and as many high, composed of *sand, clay, marine shells, and pebbles of every description*; chalk and flint pebbles were, as might be expected, most abundant."

Prof. Phillips, who examined it shortly after,[3] "found the shelly bed . . . . very irregular in its upper surface, covered by Boulder-drift, and composed of *dark sandy clay* with small black pebbles, and chalk and flint fragments, mixed with a multitude of shells, *many broken, and except Pholades and Cyprinæ, few bivalves having their valves together.* I saw no Boulder-clay beneath; upwards it seemed not sharply defined from the ordinary drift without shells, but yet distinct, so as not to pass gradually into that heterogeneous mass. . . . My own investigations led me to adopt the view that it was a shell-bed as early as the beginning of the Glacial Period (possibly Preglacial), which had been disturbed and displaced bodily by the pressure which attended the boulder-deposits, *and not stratified by dispersion under ordinary water action.* This may be expressed by the term *couche remaniée.*"

Dr. H. C. Sorby examined the bed for foraminifera, and published in 1858[4] a list of them (Appendix B), with an account of the bed. His description is the most circumstantial and complete. He says,—

"The place where the crag was then best exposed was at the bottom of the cliff, somewhat north of the town. It appeared to me to be *a number of small beds of sand and sandy clay amongst the Boulder-clay of the drift,* which occurs both below and above the part with shells, also itself containing many erratic pebbles like those in the drift. Though some few of the shells are found elsewhere, yet they are most numerous about a quarter of a mile north of the pier. The section there exhibited, at the bottom, bluish clay with pebbles of chalk and flint, as well as of other rocks transported from a distance, passing upwards into similar clay without pebbles. Above this was a very variable deposit of sandy beds and clay, similar to that below, as well as some that is brown and quite like the ordinary Boulder-clay of the district, except in containing shells.

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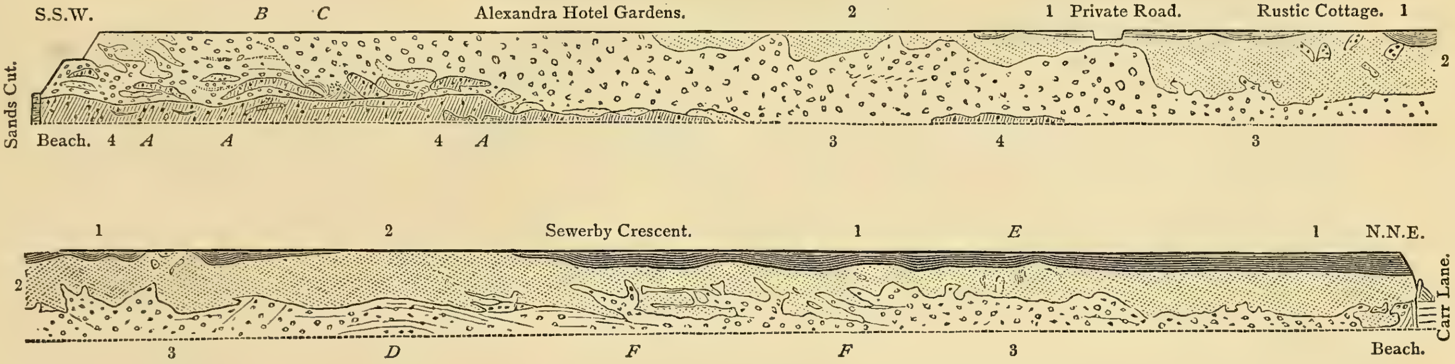
[1] Phillips' Geology of Yorkshire, 3rd edition, p. 86.
[2] The italics throughout the extracts are mine.
[3] *loc. cit.* p. 87.
[4] Proc. West Riding Geol. and Polytechnic Soc. vol. iii. p. 559.

SECTION OF THE CLIFF NOW HIDDEN BEHIND THE NEW SEA-WALL OPPOSITE THE ALEXANDRA HOTEL AT BRIDLINGTON QUAY;
AS IT APPEARED IN NOVEMBER, 1880. DRAWN BY G. W. LAMPLUGH.

SCALE, 80 feet to an inch. LENGTH OF SECTION, 380 yards. HEIGHT, 25 to 35 feet.



1 Recent Fresh-water Marl, with Shells.
2 Chalky Drift-gravel, much crushed and contorted.
3 Purple Boulder-clay.
4 Basement Boulder-clay, with included masses of Sand and Clay containing Shells at *A A A*.

A Patches of Shelly Clay and Sand in the Basement Clay.
B Strips of the Basement Clay are here torn up and dragged into the Purple Clay.
C Streaks and patches of Brown Laminated Clay, confusedly mixed with Sand and Gravel near the junction of the two Boulder-clays.
D The Purple Clay here showed grooved lines of division—most plentifully in its upper part—which appeared to the writer like planes of shearage.
E Fresh-water remains in contorted Gravel.
F The sides of these hollows and the protruding masses of clay showed slickensides.

Over this were sand and clay, and occasionally pure decomposed chalk, and then a mass of Boulder-clay of the usual description."

"The lower part of the section is much contorted, in the manner so common in the drift strata, as described by me in my paper on that subject, and there attributed to the action of icebergs. It is also well worthy of remark that the same force which produced these contortions appears to have fractured some of the shells imbedded in the clay, and displaced the fragments, which, nevertheless, may often be found within a short distance from each other. I have in my collection a number of specimens of *Saxicava rugosa* that show this fact to great advantage. Indeed, it seemed as though the exposed crag was only the upper portion of the contortions, and that the main bed was below the level of the beach, and might not have been exposed in the cliff if it had not been thus bent and raised up by lateral pressure."

So far as I know, these are the only descriptions given by eye-witnesses. It will be seen that all agree that the shells occurred in clay as well as in sand, and that the beds were fragmentary and showed many signs of pressure and disturbance. Yet, misled doubtless by the sandy matrix of most of the shells, and by the perfect condition of those which were collected,—for in a mass like this the best specimens would naturally be selected,—most geologists now seem to regard the bed as a seam of undisturbed sand with shells, in place.

Thus Messrs. Wood and Rome[1] describe the shells as occurring in a bed of sand in the lower part of the Purple Clay, and Sir C. Lyell in his 'Student's Elements'[2] refers to it as "a thin bed of sand resting on glacial clay with much chalk débris."

Three years ago, Mr. Bedwell and myself[3] were able to prove, by fragmentary shells collected from the Basement Clay, and by its position on the beach, that the shell-bed was in this division, and not in the Purple Clay; which I am now able to confirm by direct evidence.

In his latest paper[4] Mr. S. V. Wood says of the bed—"The Bridlington shells unquestionably lived where they occur, for they are in the most perfect preservation; and though the sand containing them has, in the specimens I possess, hardened to the condition of rock, the bivalves have both valves adherent and are quite unworn." I think the above-quoted extracts alone are sufficient to show that this conclusion is, to say the least, very doubtful.

Lists of the Bridlington shells have been published by Dr. S. P. Woodward,[5] Mr. S. V. Wood, jun.,[6] and Dr. J. Gwyn Jeffreys[7] (see Appendix A).

THE DIMLINGTON SHELL-BED.—Some years ago a similar shell-

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[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 149.
[2] Student's Elements, 2nd ed. p. 169.
[3] GEOL. MAG. Dec. II. Vol. V. p. 509.
[4] Quart. Journ. Geol. Soc. vol. xxxvi. p. 516.
[5] GEOL. MAG. Vol. I. p. 49.
[6] Quart. Journ. Geol. Soc. vol. xxvi. p. 92.
[7] Phillips' Geol. of Yorkshire, 3rd ed. p. 274.

bed was found in the drift at Dimlington, 32 miles south of Bridlington. The most complete account of this bed, that I have seen, is the following, by Mr. S. V. Wood, jun.[1] . . . . "The seam of sand in, but near the top of, the Basement Clay of Holderness at Dimlington, where its junction with the Purple Clay which overlies it is displayed in the cliff, was detected by a party of geologists consisting of Sir C. Lyell, Mr. Leonard Lyell, Prof. T. M. Hughes, and Mr. Rome; and a description of it was sent to me by Sir C. Lyell with the molluscan remains which they extracted. These remains, especially those of the *Nucula*, were, many of them, broken, though freshly fractured and unworn; but the written description sent me with them was that they were taken from a seam of dark sand *literally packed with perfect specimens of Nucula Cobboldiæ*, which seemed to be double; and this was certainly the condition of one of the bivalves (*Astarte compressa*) which was sent me."

Having thus summarized our present knowledge of the subject, I will record the new facts which have come under my notice.

DESCRIPTION OF THE SHELLY PATCHES RECENTLY SEEN IN THE BOULDER-CLAY AT BRIDLINGTON.—I have already mentioned that in the section opposite the Alexandra Hotel at Bridlington Quay, the Basement Boulder-clay was seen to include several masses of different materials (see section *A. A. A.*). These masses consisted for the greatest part of a very fine clay, generally either light-blue or dark bluish-black in colour; but in one place brown. This clay seemed to have been a stratified deposit; but the stratification was so nearly destroyed, that it was shown merely by irregular stripes. Coarse yellowish-green sand was incorporated with this clay in most of the patches, spreading curiously through their mass in irregular little dabs and threads forming doubtful lines, as though it had been partially kneaded in. This sand always contained many shells, which were generally crushed into fine fragments. Shells also occurred in the clays, but much less plentifully, and often with sand under the valves. The beds contained a few erratic pebbles, chiefly little black phosphatic-looking lumps (which remind me of those in one of the Lower Neocomian beds at Speeton) and a dark green quartzite. I did not notice either chalk or flint in them; in which they differ markedly from those previously described. The largest of these masses was of irregular shape, about 14 feet in its greatest length and 4 feet in height, and seemed to be crushed vertically between walls of Boulder-clay. From it I obtained the most perfect specimens. The others were much smaller, and were squeezed out so as to form wavy lenticular streaks. The junction between these and the Boulder-clay was sometimes well-marked and sometimes insensible. After finding a few of the larger shells, I washed lumps of the sand and clay, and obtained thus many small specimens, which were far less broken than the larger, and also many foraminifera and entomostraca, and two or three small echinoid spines. A few, even of the larger shells, were in an absolutely

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[1] Quart. Journ. Geol. Soc. vol. xxxvi. p. 515.

perfect state of preservation; whilst those which were broken were probably broken either during the life of the animal or very shortly after, as in one or two cases the umbos of fragmentary bivalves remained together, though much of the shell was missing; showing, I think, that the ligament existed at the time; and some fragments of *Astarte* and *Cyprina* from Dimlington showed the epidermis.

From these patches I obtained twenty-eight species of mollusca (for list see Appendix D), which Dr. J. Gwyn Jeffreys has had the kindness to examine for me, and he has named four species which are not included in the published lists of the Bridlington shells, viz. *Rissoa Wyville-Thomsoni, Menestho albula, Leda tenuis,* and *Leda lenticula.*

I have picked out twelve species and varieties of Foraminifera (see Appendix C), though doubtless a more experienced microscopist would be able to detect many more. I have to thank Mr. H. B. Brady for naming these for me.

I have seen several other patches of this kind in the Basement Boulder-clay, at various times, in exposures on the beach, to the southward of this section,[1] and nearer the place where the shells were first found, but have not before seen them in section.

It will be seen from the above-quoted descriptions of that bed, that these shelly patches are essentially the same as the so-called "Bridlington Crag," which was not really a *bed* at all in the stricter sense of the word, but a similar, though more extensive set of streaks and masses of sand and clay in Boulder-clay.

SHELLS IN BOULDER-CLAY.—The surrounding Boulder-clay also contains many shell-fragments, with now and then a perfect valve, which have undoubtedly been derived from similar beds, having been thoroughly kneaded up and mixed with glacial *débris.* This is shown by the extremely patchy nature of the clay, even where the shell-beds have been wholly destroyed, as on the south beach at Bridlington, the clay varying in character from step to step.

Then, too, under many of the unbroken valves, there still remains a little coarse sand, showing the original matrix of the shells; and many of its boulders show *Pholas* and *Clionæ* borings; and these borings contain in many instances the same coarse green sand. As not one, but several kinds of rock are bored, the bottom on which the shells lived would seem to have been strewn with boulders.

As a curious illustration of glacial erosion, I may mention the finding in this Boulder-clay, on the south beach, of a *Tellina balthica* with valves united and perfectly unbroken. Sand filled the interior, but all around was Boulder-clay,—the shell, in fact, occurred as an erratic pebble;—which, I think, shows well how misleading may be the evidence of a few selected specimens as to the general conditions of the bed from which they came; certainly no one would have judged this shell to be from the Boulder-clay.

Of twenty-five species identified from the "Basement" Clay at Bridlington (Appendix E), only one species and one variety are

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[1] GEOL. MAG. Dec. II. Vol. VI. p. 399.

not included in the published lists of the "Bridlington Crag" shells. These are *Pecten opercularis*, and *Mya truncata*, var. *Uddevallensis*.

The Dimlington Shell-beds.—I have not yet been able to find at Dimlington the bed from which Sir Charles Lyell's party obtained their shells,[1] but last spring I found streaks, identical in appearance with those at Bridlington, in an exposure of the Basement Clay on the beach a little to the north of the high land. I examined them for shells, and found many, but all crushed. I also got three large hardened casts in gritty sand of *Pholas* borings, with the *Pholas* (*P. crispata*) imbedded in the midst. Similar hardened casts are common at Bridlington. About two months ago I again saw an exposure of the Basement Clay at Dimlington,—this time of very unusual extent,—stretching for nearly a mile along the beach near low-water mark. The clay was throughout extraordinarily patchy, and was, in fact, in good part made up of masses of included material, of all sizes, and of diverse composition. Many consisted of fine blue clays mixed with sand, like those at Bridlington; and from these I obtained some very fine and perfect shells. Others however contained no shells, were almost black in colour, and seemed as if made up of the waste of some of the pyritous secondary clays, for when the sun shone hot upon them they smelt very strongly, and weathered in the cliff with a dirty yellow efflorescence and bad odour, like the lowest beds of the Lower Neocomian at Speeton. They are, indeed, quite possibly made up, in part, of these beds, as I noticed a few Neocomian fossils in Boulder-clay. Some of the patches, again, were of a rusty brown; and one of these contained a few broken shells, which were possibly derivative.

I also found in the bottom of the cliff a streak of crushed shells, much in the same position as the one already known. It ran irregularly through a mass of dark-blue clay, without stones, bounded on all sides by Boulder-clay in the same way as those on the beach; the shells, chiefly *Saxicava rugosa*, were crushed into small fragments, and the whole mass showed slickensides. In one or two cases the valves seemed to have been united. I found, some time ago, a single specimen of *Tellina balthica* uncrushed and with valves united, in a little pocket of sand near the same place.

The Boulder-clay itself was crammed in places with detached and fragmentary valves. It also contained a few huge boulders of far-travelled rocks. One mass of gneiss was about 5 feet by 2½ by 3.

From the Boulder-clay and the patches I obtained twenty-seven species (see Appendix F), of which all except two have been found at Bridlington. These are, *Thracia pubescens*, and *Cardium Grœnlandicum*.

Similar Beds in Filey Bay.—I have already recorded[2] the dis-

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[1] In the discussion which followed this paper, Prof. Hughes, one of the discoverers, satisfactorily accounted for this, as he said they took the bed away with them, it being merely a curved streak of sand in Boulder-clay, like those I have seen.

[2] Proc. Yorkshire Geol. Soc. for 1879, p. 169; and Geol. Mag. April, 1881, p. 179.

covery of an outlier of the Basement-clay, between tide-marks in Filey Bay opposite the village of Reighton; and there, too, it contained the same clay-streaks with crushed shells,—chiefly *Cardita borealis.*

These three are the only places where I have as yet seen this blue 'Basement' Boulder-clay, and the shell-streaks therefore seem to characterize it.

STRATIGRAPHICAL RELATIONS OF THE SHELLY BOULDER-CLAY.—Though I have throughout called this shelly Boulder-clay the 'Basement Clay,' to describe its position in the series, it is not, perhaps, quite correct to do so, as Messrs. Wood and Rome, who established this division, trace it in many places where the shelly clay does not exist, making it extend along the base of the cliff from Dimlington northwards to beyond Hornsea.[1] These gentlemen have, I think, included in their division a hard massive Boulder-clay, greyish in colour and very full of chalk, which overlies the shelly clay on both north and south sides of Dimlington Heights; but it is somewhat irregular and intermittent under Dimlington, having apparently suffered severe erosion. Shells, even in fragments, are very rare in it,—rarer even than in the overlying Purple Clay.

This chalky clay is, I think, more closely connected with the 'Purple' than with the shelly clay; but should it eventually be retained as the top of the 'Basement Clay,' the shelly clay must be described as a zone in that division.

Above the chalky clay at Dimlington there are in places twenty feet of bedded sands and fine clays with no fossils, and then the Purple Clay, often in two divisions.

At Bridlington, the shelly clay, wherever it comes below beach-level, is overlaid by a finely laminated and in places ripple-marked clay of a deep brown colour,—very tough and unctuous,—containing no stones, and varying from two to sixteen feet in thickness, as it fills and levels hollows in the lower clay; but as soon as the top of that clay rises above the beach-line, the laminated clay disappears, and the Purple and Shelly Clays come together as in the section under the Alexandra.

This is probably owing to erosion during the formation of the Purple Clay, as, in the section just referred to, masses and bands of the lower clay were seen twisted upwards for some distance into the Purple Clay (at *B*), just as the Purple Clay into the gravels a little further north; and there were also one or two detached patches of laminated clay agreeing in appearance with this bed in the lower part of the Purple Clay (at *C*). I obtained another proof of the later disturbance which the whole mass of the lower clay must have suffered: for in it, under the Alexandra, one of the many stones with Pholas borings—a hard calcareous nodule which still held the hardened green sand in the holes, and had been afterwards striated—had been broken in two as it lay deep in the clay, and the parts

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[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 148.

separated by about three inches, probably by the shearing of the whole mass of the clay under pressure.

I have not seen a representative of the chalky clay above the shelly clay at Bridlington, though from the already-quoted descriptions given by Prof. Phillips and Dr. Sorby of that part of the cliff now concealed, it is possible that such may exist.

As the shelly clay reaches low-water mark at Dimlington and Bridlington, I can give no account of its thickness, nor of the underlying beds.

Origin and Formation of the Beds.—As there are points connected with these beds that I do not yet understand, it would be useless for me to attempt to explain their origin. Thus, one point —and this bears strongly on the origin of the shelly patches— is the peculiarly restricted range of the shells, and the difference between the fauna of patches almost adjoining. For instance, at Dimlington nowhere did I find *Dentalium striolatum*, save in one small patch, where, from a mere handful of clayey sand, I obtained the remains of over a dozen individuals. In another patch I found *Natica affinis*,—in another, a few fragments of *Nucula Cobboldiæ*,— in another, *Pecten Islandicus;* and so on; in each case associated with a few forms such as *Tellina balthica*, *Saxicava rugosa*, *Astarte borealis*, and *A. sulcata*, var. *elliptica*, which occurred in varying proportions nearly everywhere. It was the same at Bridlington. There, in the largest mass, several shells were found which were not present in the smaller patches; and in one of the latter *Pleurotoma turricula* was the most abundant shell, and was peculiar to it. Thus, again, some years ago Mr. Bedwell obtained *Cyprina Islandica* with valves united, though much crushed, from an exposure on the beach near the original bed, but nowhere have I seen this shell in place, though fragments of it, derived from some such bed, are plentiful in the Boulder-clay. *Tellina balthica*, too, is far more plentiful in the Boulder-clay than in any of the shell-patches I have seen.

Now this, coupled with their diverse composition, shows that the masses have been brought together from different depths and localities,—a result which does not seem to me to be exactly what we should expect to be brought about either by land or floating ice. It has, perhaps, been produced by a combination of both, since, I suppose, an ice-sheet advancing over a sea-bottom would necessarily throw out before it a thin fringe of bergs, whose pioneer work on unbroken ground even the passage of the main mass might not entirely obliterate. Or, it may have been caused by the passage of the eroding agent over the edges of an older series of variable beds; but much of the evidence discountenances this view.

At any rate, I think the coarse sand was the true old sea-bottom on which the shells lived; and that this sea-bottom was afterwards covered by a thick deposit of glacial mud; and then the whole subjected to some disturbing force,—ice in some form no doubt,— which removed it piecemeal; perhaps in frozen masses.

In the Appendices I give full lists of the shells.

Postscript.—Since writing the above, the storms of this autumn cleared the shingle from a small extent of beach near the town and close to where the 'Crag' was first found. This exposure showed 'Basement Clay' of the usual character, including in it one large mass of clay and sand with shells, and closely adjoining another similar mass of fine dark mud, without shells or stones; and through this there ran a short seam of peaty matter apparently of vegetable origin. It is not improbable therefore that some of these shell-less patches may be of fresh-water origin.

Appendix A.—List of the Bridlington Shells published by Dr. J. Gwyn Jeffreys, F.R.S., in Phillips' Geology of Yorkshire, 3rd ed. p. 274.

BRACHIOPODA.

1 *Rhynchonella psittacea.*

CONCHIFERA.

2 *Anomia ephippium.*
3 *Pecten Islandicus.*
4 *Mytilus edulis.*
5 ,, *modiolus.*
6 *Nucula Cobboldiæ.*
7 ,, *tenuis;* and var. *inflata.*
8 *Leda minuta;* and var. *buccata.*
9 ,, *pernula.*
10 ,, *limatula.*
11 *Pectunculus glycimeris.*
12 *Montacuta bidentata.*
13 *Cardium Islandicum.*
14 ,, *edule.*
15 *Cardita borealis.*
16 *Cyprina Islandica.*
17 *Astarte sulcata*; and var. *elliptica.*
18 ,, *depressa.*
19 ,, *borealis;* and var. *Withami.*
,, and monstr. *mutabile.*
20 ,, *compressa.*
21 *Venus fluctuosa.*
22 *Tellina balthica.*
23 ,, *calcaria;* and var. *obliqua.*
24 *Donax vittatus.*
25 *Mactra solida;* var. *elliptica.*
26 *Thracia prætenuis.*
27 *Corbula gibba.*
28 *Mya arenaria.*
29 ,, *truncata.*
30 *Saxicava Norvegica.*
31 ,, *rugosa.*
32 *Pholas crispata.*

SOLENOCONCHIA.

33 *Dentalium entale.*
34 ,, *striolatum.*

GASTEROPODA.

35 *Lepeta cæca.*
36 *Puncturella noachina.*
37 *Trochus varicosus.*
38 *Littorina litorea.*
39 ,, *rudis.*
40 *Turritella terebra.*
41 ,, *erosa.*
42 *Scalaria Grœnlandica.*
43 *Natica Islandica.*
44 ,, *Grœnlandica.*
45 *Natica affinis;* and var. *occlusa.*
46 ,, *Montacuti.*
47 *Trichotropis borealis.*
48 *Admete viridula.*
49 *Purpura lapillus,*
50 *Buccinum undatum.*
51 *Trophon truncatus.*
52 ,, *clathratus;* and var. *Gunneri.*
53 ,, *Fabricii.*
54 ,, *latericeus.*
55 *Fusus despectus*; and monstr. *contrarium.*
56 ,, *Leckenbyi.*
57 ,, *curtus;* and var. *expansa.*
58 ,, *Spitzbergensis.*
59 ,, *propinquus.*
60 ,, *Sarsi.*
61 *Columbella rosacea.*
62 *Pleurotoma pyramidalis.*
63 ,, *violacea.*
64 ,, *elegans.*
65 ,, *turricula:* and vars. *nobilis* and *exarata.*
66 ,, *harpularia.*
67 ,, *Trevelyana.*

Appendix B.—List of Foraminifera given by Dr. H. C. Sorby, F.R.S., in his paper on the Bridlington Crag, Proc. West Riding of Yorkshire Geol. and Polytechnic Soc. vol. iii. p. 559.

Dentalina communis.
Lagena striata.
Polymorphina lactea.
Quinqueloculina seminulum.
Robulina calcar ?
Truncatulina tuberculata.

And undetermined species of

Biloculina.
Guttulina.
Nonionina.
Triloculina.

Also two Entomostraca

Cytheridea Sorbyana.
Cytherea concinna.

See also Prof. T. Rupert Jones and W. K. Parker, GEOL. MAG. Vol. I. p. 55, and Palæontographical Society.

APPENDIX C.—LIST OF FORAMINIFERA OBTAINED FROM INCLUDED MASSES OF SAND AND CLAY IN THE BASEMENT BOULDER-CLAY AT BRIDLINGTON, 1881.

Miliolina seminulum.
Lagena lævis.
,, *globosa.*
Dentalina pauperata.
Glandulina lævigata, running into varieties
Glandulina rotundata.
Glandulina æqualis.
Cassidulina lævigata.
Cassidulina crassa.
Nonionina depressula.
Polystomella striato-punctata.
Pulvinulina Karsteni.

I have to thank Mr. H. B. Brady, F.R.S., for his kindness in naming the above for me. He says, "As far as they go, they indicate a cold sea-bottom of 80 to 100 fathoms, not unlike some parts north of Shetland (the Faroe Channel, etc.)."

APPENDIX D.—LIST OF MOLLUSCA OBTAINED FROM THE INCLUDED MASSES OF SAND AND CLAY IN THE 'BASEMENT' BOULDER-CLAY AT BRIDLINGTON, 1881.

1 *Pecten Islandicus.*
2 *Nucula Cobboldiæ.*
3 *Leda limatula.*
*4 LEDA TENUIS (fry).
*5 LEDA LENTICULA.
6 *Cardium Islandicum.*
7 *Cardita borealis.*
*8 *Astarte sulcata;* var. *elliptica.*
*9 ,, *borealis.*
*10 ,, *compressa;* and var. *striata.*
*11 *Tellina balthica.*
12 ,, *calcaria.*
13 *Mya truncata.*
*14 *Saxicava rugosa.*
15 *Saxicava Norvegica.*
16 *Dentalium entale.*
*17 *Trochus varicosus* (fry).
18 *Turritella erosa.*
*19 *Natica Islandica.*
*20 ,, *Grœnlandica.*
*21 ,, *affinis.*
*22 RISSOA WYVILLE-THOMSONI.
*23 MENESTHO ALBULA.
*24 *Trophon clathratus.*
25 *Fusus despectus.*
26 ,, *Sarsi.*
27 *Admete viridula.*
*28 *Pleurotoma turricula.*

The species printed in capitals are additions to the Bridlington fauna. Unbroken specimens were obtained of those marked with an asterisk (*).

APPENDIX E.—LIST OF MOLLUSCA (MOSTLY FRAGMENTARY) OBTAINED FROM THE 'BASEMENT' BOULDER-CLAY AT BRIDLINGTON.

1 PECTEN OPERCULARIS.[1]
2 ,, *Islandicus.*
3 *Nucula Cobboldiæ.*
4 *Leda pernula.*
5 *Pectunculus glycimeris.*
6 *Cardium edule.*
7 ,, *Islandicum.*
8 *Cyprina Islandica.*
9 *Astarte sulcata*, var. *elliptica.*
10 ,, *borealis.*
11 ,, *compressa.*
12 ,, *depressa.*
13 *Tellina balthica.*
14 ,, *calcaria.*
15 *Mya arenaria?*[1]
16 ,, *truncata.*
17 MYA TRUNCATA var UDDEVALLENSIS
18 *Saxicava rugosa.*
19 ,, *Norvegica.*
20 *Pholas crispata.*
21 *Dentalium entale.*
22 *Turritella erosa.*
23 *Buccinum undatum.*
24 *Fusus curtus.*
Also *Balanus crenatus.*
,, *sulcatus.*
,, *tintinnabulum*, and
Cliona perforens.

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[1] From the list published by me in the GEOL. MAG. Nov. 1878, and not since verified.

Appendix F.—List of Mollusca obtained from the Shelly 'Basement' Boulder-Clay and included masses at Dimlington.

1 *Pecten Islandicus.*
2 *Mytilus modiolus.*
3 *Nucula Cobboldiæ.*
4 ,, *tenuis.*
5 *Leda pernula.*
6 *Cardium edule.*
7 CARDIUM GRŒNLANDICUM.
8 *Cyprina Islandica.*
9 *Astarte depressa.*
*10 ,, *borealis;* and var.
*11 ,, *sulcata,* var. *elliptica.*
*12 ,, *compressa.*
*13 *Tellina balthica.*
14 ,, *calcaria.*
*15 *Mactra solida,* var. *elliptica.*
16 THRACIA PUBESCENS.
17 *Mya truncata.*
*18 *Saxicava rugosa.*
19 ,, *Norvegica.*
*20 *Pholas crispata.*
*21 *Dentalium entale.*
22 ,, *striolatum.*
23 *Turritella erosa.*
*24 *Natica affinis.*
25 *Fusus despectus.*
26 ,, *Spitzbergensis.*
*27 *Pleurotoma pyramidalis.*
Also *Balanus Hameri.*
,, *crenatus.*

As in the Bridlington list, the asterisk denotes that the shell has been obtained unbroken. The two species in capitals have not been found at Bridlington.

Dr. J. Gwyn Jeffreys remarks that he considers all these shells "comparatively shallow water species, from 2 to 10 fathoms. They are unmistakeably arctic."

Appendix G.—The following are the additions in the above lists to the Bridlington Molluscan Fauna as contained in Appendix A.

1 *Pecten opercularis.* Bridlington.
2 *Leda tenuis.* Bridlington.
3 *Leda lenticula.* Bridlington.
4 *Cardium Grœnlandicum.* Dimlington.
5 *Thracia pubescens.* Dimlington.
6 *Mya truncata,* var. *Uddevallensis.* Bridlington.
7 *Rissoa Wyville-Thomsoni.* Bridlington.
8 *Menestho albula.* Bridlington.

I have great pleasure in thanking Dr. J. Gwyn Jeffreys for his kindness in examining for me the great number of shells, chiefly fragmentary, from which these lists are compiled; and also my friend Mr. W. Headley, of Bridlington Quay, for his valuable assistance in procuring specimens.

III.—On the Parallelism of the Hanoverian and English Upper Jurassic Formations. By C. Struckmann.

Communicated by the Translator, W. S. Dallas, F.L.S.;
Assistant-Secretary, Geological Society of London.

[M. C. Struckmann, who has already published an elaborate treatise on the Upper Jura of the neighbourhood of Hanover, has communicated to the "Neues Jahrbuch für Mineralogie, etc." (1881, Bd. II. pp. 77—102), a comparison, founded mainly upon palæontological evidence, between the Upper Jurassic deposits of that district and England, and a statement of the conclusions at which he arrives will be interesting to many English geologists.

He commences with an abstract of the authorities on which he founds his knowledge of the English deposits, referring especially to certain recent memoirs, such as that "On the Corallian Rocks of England," by Messrs. Blake and Hudleston;[1] that "On the Kimmeridge Clay of England," by the Rev. J. F. Blake,[2] and the important paper "On the Portland Rocks of England," by the latter author.[3]

In using the palæontological details given in these and other works on the English Upper Jurassic rocks for the formation of a comparative table of common fossils, M. Struckmann has accepted only those species about the determination of which there was no doubt, so that there is no room for erroneous results arising from differences of interpretation. On the whole he has adopted the subdivisions established by the English authors in the Upper Jurassic rocks; but he has united their Lower Calcareous Grit (Nothe Grit) and Lower Limestone (Nothe Clay, Hambleton Oolite) with the upper region of the underlying Oxford Clay (zone of *Ammonites biarmatus*); and has also combined the Middle Calcareous Grit, the Coralline Oolite, and the Coral Rag in a single division. A part of the Coral Rag, however, may be the equivalent of the Supracoralline Beds. Upon the evidence derived from these memoirs and his own investigations of the fossils of the corresponding Hanoverian deposits, M. Struckmann has constructed an elaborate table showing the horizons at which the common species, 125 in number, occur, and the results of this table for the great classes of organisms he summarizes as follows (see next page):—

The conclusions at which M. Struckmann arrives from the study of this table are as follows]:—

1. In all, the table shows 125 species of fossil remains of animals which are common to the English and Hanoverian Upper Jurassic series. Of these, nearly half (48 per cent.) belong to the Bivalve Mollusca, 21 per cent. to the Gasteropods, 12 per cent. to the Echinoids, 6·4 per cent. to the Cephalopods, and 4·8 per cent. to Corals. The number of Cephalopoda is comparatively very small, a circumstance due to the extraordinary poverty of the North-German Upper Jura, and especially its upper portions, in remains of this class of animals. On the other hand, the Echinoidea are comparatively strongly represented, which may be because, both in England and North Germany, they have been within the lsat few years subjected to a thorough monographic treatment, and are therefore better known than other classes of animals. With regard to the Corals, I am convinced, says M. Struckmann, that a considerably larger number of common species will be recognized, as soon as the Corals of the North-German Upper Jura have been worked out monographically.

The table shows at once that the agreement of palæontological conditions is much greater in the lower part of the Upper Jurassic formations than in the higher deposits, a phenomenon by no means of isolated occurrence; for I have already shown[4] that the Oxfordian

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[1] Quart. Journ. Geol. Soc. 1877, p. 260.

[2] Quart. Journ. Geol. Soc. 1875, p. 196.

[3] Quart. Journ. Geol. Soc. 1880, p. 180.

[4] Der Obere Jura der Umg. von Hannover, p. 166.

A COMPARATIVE TABLE SHOWING THE FOSSILS COMMON TO THE ENGLISH AND HANOVERIAN UPPER JURASSIC SERIES.

	ENGLAND.								HANOVER.								
												Lower Kimmeridge.					
	Lower Calcareous Grit and Lower Limestone.	Middle Calcareous Grit, Coralline Oolite, and Coral Rag.	Upper Calcareous Grit, and Supracoralline Beds.	Kimmeridge Passage-beds of Blake.	Lower Kimmeridge Clay of Blake.	Upper Kimmeridge Clay of Blake.	Portland Sand.	Portland Stone.	Hersumer Beds.	Lower Coralline Oolite.	Upper Coralline Oolite.	Zone of *Terebratula humeralis.*	*Nerinæa*-beds.	*Pteroceras*-beds, or Middle Kimmeridge.	*Virgula*-beds, or Upper Kimmeridge.	Lower Portland.	Upper Portland.
6 Anthozoa	...	6	...	...	...	...	...	...	2	6	1	1	...	...	...	...	...
1 Crinoidea	1	1	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...
15 Echinoidea	4	15	5	1	...	...	...	...	2	12	8	5	...	2	1	...	...
2 Brachiopoda	...	1	1	...	...	...	...	...	...	1	...	1	1	1	1	1	...
60 Conchifera	12	28	16	15	16	2	10	12	17	26	11	13	15	35	16	8	5
26 Gasteropoda	2	11	6	3	3	...	...	8	2	4	11	3	8	12	2	1	...
8 Cephalopoda	5	6	1	...	2	...	...	1	7	1	1	...	...	...	...	1	...
3 Annulata	...	...	1	...	...	...	...	2	...	1	...	1	1	2	...	1	1
4 Pisces	...	...	...	...	4	...	...	...	...	...	1	3	1	3	...	2	...
Summary	24	68	30	19	25	2	10	23	30	52	33	27	26	55	20	14	6

beds and the Coralline Oolite almost everywhere display a very similar fauna, whilst the development of local faunas commences with the Kimmeridge, so that, in the case of the higher deposits of the Upper Jura, the palæontological material alone does not suffice for comparison and correlation.

2. From the *Lower Calcareous Grit* (including the upper region of the Oxford Clay with *Ammonites cordatus, A. athleta* and *Ostrea dilatata*) and the Lower Limestone, 24 species, and among them 12 Conchifera, 4 Cephalopoda, and 4 Echinoida, occur also in the Hanoverian Jura.

a. Of these 24 species, 16 occur in the Hersumer beds of Hanover, and 6 of these (*Thracia pinguis, Belemnites hastatus, Ammonites cordatus, A. arduennensis, A. perarmatus,* and *A. athleta*) have not hitherto been found in any higher beds, while the other 10 species also occur in the Coralline Oolite. It is further to be remarked that in England 20 of these 24 species belong in common to the Lower and Middle Calcareous Grits, whilst only 3 species are confined to the lowest zone.

b. The other 8 species do not occur in Hanover in the Hersumer beds, but in the Coralline Oolite,—6 in the Lower and 2 in the Upper Coralline Oolite. Considering the near affinity of the inferior zones of the Upper Oolite both in England and in North Germany, this is not at all surprising. On the contrary, from the conditions of stratification and the close palæontological relationship, it cannot be doubted that the Lower Calcareous Grit and the Lower Limestone together, and including the upper region of the underlying Oxford Clay, represent the North-German Hersumer beds, *i.e.* the South-German zones of *Ammonites biarmatus* and *A. transversarius,* taken together. No separation of the Hersumer beds into two zones is practicable in North Germany, so far as my observations go.

3. The *Middle Calcareous Grit,* including the Coralline Oolite and Coral Rag, contains the great number of 68 species of fossil remains of animals, which also occur in the Upper Jura of Hanover, and among them 6 Corals, 15 Echinoids (or the whole of the known common species), 6 Cephalopods, 28 Bivalve Mollusca, and 11 Gasteropods.

a. Of these 68 species there are:—

In the Hanoverian Coralline Oolite generally	57	species.
Only below, *i.e.* in the Hersumer beds	6	,,
Only above the Coralline Oolite	5	,,

Of the first-mentioned 57 species, 16 have hitherto been found near Hanover only in the Coralline Oolite, and among them are:—*Cidaris florigemma, Hemicidaris intermedia, Pygurus pentagonalis, Stomechinus gyratus,* * *Echinobrissus dimidiatus,* * *Emarginulina Goldfussii,* * *Turbo princeps,* * *Phasianella striata, Natica Clio,* and *Nerinæa visurgis.*

The species marked with an asterisk are also limited to this division in England so far as is at present known.

b. Of the 68 species of the Middle Calcareous Grit, etc., there are, near Hanover:—

Peculiar to the *Lower* Coralline Oolite	55	species.
Only occurring lower	6	,,
Only higher (including 2 species in the Upper Coralline Oolite)	7	,,

Only 25 species are peculiar to the *Upper* Coralline Oolite, so that the palæontological affinity to the Lower Coralline Oolite is considerably greater. Of the above 55 species, the following 11 species are, so far as at present known, limited to the Lower Coralline Oolite, namely:—*Montlivaltia subdispar*,* *Thamnastræa arachnoides*,* *Isastræa explanata*,* *Millericrinus echinatus*, *Pseudodiadema hemisphœricum*,* *Glypticus hieroglyphicus*,* *Pygaster umbrella*,* *Pecten inæquicostatus*,* *Lima densepunctata*,* *Opis Phillipsiana*, and *Isodonta Deshayesea*.*

The species marked with an asterisk are confined in England also to this division according to the evidence before me.

Hence it cannot be at all doubtful that we must seek the parallels for this middle division of the "Corallian Rocks" in the North German Coralline Oolite, and indeed especially in the *Lower Coralline Oolite* (*Crenularis*-beds of the Aargau according to Moesch, "Rauracien inférieur" of Tribolet, "Séquanien inférieur" of the Haute-Marne of P. de Loriol, beds with *Ammonites bimammatus* (inferior zone) or beds with *Cidaris florigemma* (inferior zone) of Oppel). The agreement in the stratigraphical and palæontological conditions may be characterized as complete.

4. The *Supracoralline beds* (Upper Calcareous Grit) in England show 30 species which also occur in the Hanoverian Upper Jura, and among them are 4 Echinoids, 16 Conchifera, and 6 Gasteropods.

a. Of the 30 species there belong

To the Hanoverian Coralline Oolite in general	22	species.
Only to lower beds (*Pholadomya hemicardia*)	1	,,
Only to higher beds, *i.e.* the Kimmeridge	7	,,

These last species are:—*Terebratula subsella*, *Arca superba*, *Nucula Menkei*, *Astarte supracorallina*, *Pleuromya tellina*, *Corbula Deshayesea* and *Natica Eudora*.

b. On the other hand, there are of the 30 common species

In the Hanoverian Kimmeridge in general	12	species.
Only in lower beds	18	,,

Of the last-mentioned 18 species, eight, according to extant observations, belong exclusively to the Coralline Oolite, namely:—*Cidaris florigemma*, *Hemicidaris intermedia*, *Pygurus pentagonalis*,* *Ostrea deltoidea*, *Goniomya marginata*, *Trochus exiguus*,* *Chemnitzia pseudolimbata* and *Natica Clio*.* Of these the three species marked with an asterisk are peculiar to the Upper Coralline Oolite, and the other five species to the Lower Coralline Oolite; ten species also occur in the Hersumer beds, among which are *Pecten vimineus*, *Lima rigida*, *Ammonites plicatilis*, and *Collyrites bicordatus*, species which, with us, are characteristic of a lower horizon.

c. Of the 12 species which are found in the North-German

Kimmeridge, 10 species belong to the Lower Kimmeridge, while 2 species occur only in Upper Kimmeridge beds.

From these comparisons it appears that the fauna of the Supracoralline beds is a mixed one, which unmistakeably shows close relations both with the Coralline Oolite and with the Lower Kimmeridge. Nevertheless, the relations downwards, *i.e.* to the Coralline Oolite, seem to me undoubtedly to preponderate. In this respect the Supracoralline beds occupy a position precisely similar to that of the Upper Coralline Oolite (zone of *Pecten varians*) in the North-German Upper Jura, so that I do not think I shall err in placing the two parallel to one another. This notion certainly does not seem to be quite in accordance with the opinion expressed by Waagen, who regards the region of *Ammonites alternans* and *Rhynchonella inconstans* in the English Upper Jura as the equivalent of the Astartian, *i.e.* of the Lower Kimmeridge; but it appears from Blake's investigations that the two species do not at all belong to one and the same zone, but that *Ammonites alternans* rather characterizes the Supracoralline beds, and *Rhynchonella inconstans* the Kimmeridge Passage-beds, or the next higher zone. This, therefore, serves to explain the apparent contradiction, the region of *Rhynchonella inconstans* really corresponding to the Astartian, and all we have to do is to separate the older stage with *Ammonites alternans* from the Kimmeridge and annex it to the Coralline Oolite as the uppermost stage. The occurrence of *Ammonites alternans* in the Supracoralline beds (it is entirely wanting in the North-German Jura) cannot alone be a reason for regarding the latter as of the same age as the zone of *Ammonites tenuilobatus*, for the fauna of the Upper Jurassic formations in different districts teaches us how little dependence is to be placed upon so-called characteristic fossils. *Ostrea deltoidea* also offers an interesting example of this; in England it appears first in the Supracoralline beds, and then attains the climax of its development in the Lower Kimmeridge. In the North-German Jura I have recently determined the same species most definitely from Hanover, Hoheneggelsen and Goslar; but here it is exclusively confined to the Coralline Oolite. (*Ostrea Rœmeri*, Quenst., which occurs in the zone of *Terebratula humeralis*, is *not*, as D. Brauns supposes, identical with *O. deltoidea.*) On the other hand, *Terebratula subsella* has hitherto been found in England only in the Supracoralline beds; while in North Germany it extends up from the Lower Kimmeridge into the Portland. I shall hereafter take the opportunity of citing other similar examples. Consequently, I have no hesitation in regarding the Supracoralline beds as equivalent to the North-German Upper Coralline Oolite (*i.e.* the zone of *Pecten varians*), the Wangen beds of Eastern Switzerland, the Rauracien supérieur of Western Switzerland, the Séquanien supérieur of the Haute-Marne (according to P. de Loriol), relatively, as the uppermost horizon of the beds with *Cidaris florigemma*, and with *Ammonites bimammatus* (according to Waagen) and the Séquanien inférieur of Boulogne-sur-Mer (according to P. de Loriol).

5. The *Kimmeridge Passage-beds* according to our present know-

ledge contain 19 species of the Hanoverian Upper Jura, namely, 1 Echinoid, 15 Bivalves, and 3 Gasteropods.

a. Of these 19 species, 12 are observed in the Hanoverian Coralline Oolite in general; on the other hand, exclusively in the Kimmeridge, 7 species, namely:— *Ostrea Monsbeliardensis, Exogyra Bruntrutana, Pinna granulata, Ceromya excentrica, Pleuromya tellina, Natica Eudora* and *Lucina plebeia.*

On the other hand, 14 species occur in the Hanoverian Kimmeridge in general, and only in lower beds 5 species. Of the latter, two species (*Chemnitzia heddingtonensis* and *Lima proboscidea*) go down into the Hersumer beds, while three species are peculiar to the Coralline Oolite in North Germany, namely, *Cidaris florigemma, Phasianella striata,* and *Ostrea deltoidea.* Among the species which are found both in the Kimmeridge and in lower beds, *Lucina substriata* must also be mentioned; this only attains the climax of its development in the Kimmeridge.

b. Of the 14 species which occur in the Hanoverian Kimmeridge, 12 appear in the Lower Kimmeridge (Astartian), while only 2 species (*Pinna granulata* and *Natica Eudora*) belong exclusively to Upper Kimmeridge beds. It is true that the first-mentioned 12 species are not exclusively confined to the Lower Kimmeridge; 9 species ascend to a higher horizon.

It appears, therefore, from this comparison, as indeed is indicated by Blake, that the Kimmeridge Passage-beds also possess a mixed fauna. But while in the case of the Supra-coralline beds the downward relationships, *i.e.* to the Coralline Oolite, are preponderant, the fauna of the so-called Passage-beds decidedly bears rather the character of the Kimmeridge formations, and indeed of their lower division, so that I have not the least hesitation about placing the English beds with *Rhynchonella inconstans* parallel to the Hanoverian Lower Kimmeridge. The characteristic shell of this zone does not indeed occur in the North-German Jurassic deposits, for the species cited by some observers under this name from the Coralline Oolite, especially from Goslar, is erroneously referred to the English species, and is rather a large variety of *Rhynchonella pinguis*, A. Röm., or, more probably, a new species. The conditions of stratification are quite in accordance with the opinion expressed by me. I therefore regard the Kimmeridge Passage-beds as also the equivalent of the zone of *Ammonites tenuilobatus* in Swabia, of the Badener beds of Eastern Switzerland, of the Astartian of Western Switzerland, and of the Séquanien supérieur of the Haute Marne, and of Boulogne-sur-Mer, according to P. de Loriol. This assumption is further borne out by the reciprocal palæontological relations of the immediately following Kimmeridge beds.

6. The *Lower Kimmeridge Clay* possesses 25 species of fossil remains which also occur in the Hanoverian Upper Jura, namely, 16 Bivalves, 3 Gasteropods, 2 Cephalopods, and 4 Fishes. Of these there have been observed near Hanover:—

In the Kimmeridge generally	22 species.
Only in lower beds	3 ,,
In the Lower Kimmeridge generally	14 ,,
In the Middle Kimmeridge generally	19 ,,
Exclusively in the Kimmeridge	17 ,,

Of the last-mentioned, *Ostrea Monsbeliardensis*, *Neritopsis delphinula* and *Hybodus acutus*, have hitherto been found only in the Lower Kimmeridge; and *Pinna granulata*, *Mactromya rugosa*, *Corbula Deshayesea*, and *Alaria nodifera*, only in the Middle Kimmeridge or higher. On the other hand, *Exogyra virgula*, *Arca rustica*, *Nucula Menkei*, *Astarte supracorallina*, *Cardium eduliforme*, *Isocardia striata*, *Ceromya excentrica*, *Pleuromya tellina*, *Tornatella secalina*, and *Lepidotus giganteus* are distributed through different zones of the North-German Kimmeridge. Lastly we have to mention *Lucina substriata*, *Ostrea solitaria*, and *Asteracanthus ornatissimus* as species which occur in the Middle Kimmeridge, near Hanover, but at the same time extend down into the Coralline Oolite.

Between the English Lower Kimmeridge Clay and the Hanoverian Kimmeridge a tolerably close palæontological relationship therefore exists, although the phase of development is quite different. For while the Lower Kimmeridge Clay presents a very rich and varied Cephalopodal fauna, the North-German Kimmeridge is in this respect remarkably poor. Nevertheless both the conditions of stratification and the fauna indicate that the parallel is to be sought in the North-German *Pteroceras*-beds (*i.e.* in the Middle Kimmeridge beds). It is true that the so-called characteristic fossils furnish even in this case no satisfactory standpoint; *Ostrea deltoidea*, so abundant in the Lower Kimmeridge, occurs near Hanover only in lower deposits; and on the other hand, *Pteroceras oceani* has hitherto been found in England only in a higher zone. But it appears to me to be not unimportant that both in the English Lower Kimmeridge and in the North-German *Pteroceras*-beds the remains of higher animals, namely, Saurians, Chelonians, and Fishes, are deposited in great variety, although as yet we have succeeded in determining the species only in a few instances. Notwithstanding the divergence of the phase of development in many respects, the fauna of the North-German Middle Kimmeridge beds bears on the whole the character of the English Lower Kimmeridge Clay, so that the palæontological conditions are not in opposition to a parallelism. At any rate, the development of the South- and North- German Kimmeridge exhibits considerably greater differences. If, therefore, the Lower Kimmeridge Clay must be regarded as the equivalent of the *Pteroceras*-beds, then, in accordance with my previous demonstrations (in my monographic memoir upon the Upper Jura of the neighbourhood of Hanover), the Nattheim Coralline Limestone of Swabia (ϵ of Quenstedt), the Wettinger beds of Eastern Switzerland, as also the Ptérocérien of Western Switzerland and the French Upper Jura, are to be considered contemporaneous deposits.

7. I have already indicated elsewhere[1] that the comparison of the

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[1] Der obere Jura d. Umg. v. Hannover, p. 166.

Upper Jurassic formations of different regions is rendered very much more difficult by the fact that almost everywhere with the Kimmeridge the development of local faunas commences, and the species are very differently distributed in the different zones. This appears very prominently in the comparison of the higher beds of the Upper Jurassic in England and Hanover.

The *Upper Kimmeridge Clay* in England contains a fauna so completely different from that of the North-German Kimmeridge, that hitherto only two fossils have been determined which also belong to the Hanoverian Jura, namely, *Exogyra virgula* and *Gervillia tetragona*, species found both in the Middle and Upper Kimmeridge. Nevertheless, as follows especially from the following statements, it cannot be doubtful, that the Upper Kimmeridge Clay and the Hanoverian Upper Kimmeridge (*Virgula* beds) were deposited at about the same time.

8. To estimate correctly the reciprocal relations of the English and Hanoverian *Portlandian beds*, I have to call attention to the fact that, according to my recently published investigations on the Hanoverian Wealden,[1] the English and North-German Wealden deposits have been developed in a perfectly concordant manner. In both districts the uppermost horizon is occupied by the Weald Clay (Upper Wealden), which is certainly considerably more strongly developed in England, so that the Wealden period there probably had a longer duration than in North Germany. Below the Weald Clay lies the Hastings Sand (Middle Wealden), which in turn overlies the Purbeck Beds (Serpulite or Lower Wealden). The assumed parallelism is borne out both by the conditions of stratification and by the distribution of organic remains in the different divisions. In England the Purbeck beds rest immediately upon the Portland Stone, and the latter on the Portland Sand; below this follows the Upper Kimmeridge Clay. In Hanover, on the other hand, taking the reversed order, the Upper Kimmeridge (*Virgula*-beds) is immediately overlain by the beds with *Ammonites gigas* (*i.e.* the Lower Portland); these are followed regularly by the Eimbeckhäuser Plattenkalke (*i.e.* the Upper Portland), which again are covered by the Münder Mergelen, and finally comes the Serpulite, which undoubtedly represents the English Purbeck. Necessarily, therefore, the deposits between the Kimmeridge and the Purbeck must be of the same age as the English Portland Stone and Portland Sand, whether we refer the transition stage between the Eimbeckhäuser Plattenkalke and the true Purbeck (*i.e.* the Münder Mergel) to the Portland or the Purbeck. The supposition entertained by some authorities that the English Portland formations are entirely unrepresented in North Germany is therefore certainly an error, due solely to the circumstance *that the English and Hanoverian Portland formations assume an entirely different phase of development*, as indeed frequently happens in the Upper Jura. This circumstance must not be left out of consideration in comparing the English and Hanoverian Portland faunas.

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[1] Die Wealden-Bildungen d. Umg. v. Hannover, pp. 115, *et seqq.*

a. According to the lists before us the *Portland Sand* contains only 10 species of fossils, all Conchifera, which are also found in the Hanoverian Upper Jura. Of these only 4 species have hitherto been observed in the Portland formations, namely, *Ostrea multiformis* and *Perna Bouchardi,* in both divisions, and *Trigonia variegata* (which, as is well known, is very nearly allied to *T. gibbosa*) and *Pleuromya tellina* as yet only in the Plattenkalke. Six species do not occur above the Kimmeridge beds, namely, *Ostrea solitaria, Ostrea Bruntrutana, Mytilus jurensis, Trigonia alina, Lucina fragosa,* and *Plectomya rugosa.* The whole of the 10 species are contained in the *Pteroceras*-beds. The characteristic fossil of the German and French Lower Portland formations, *Ammonites gigas,* has not yet been detected in the English Portland Sand; on the other hand, *Ammonites giganteus,* Sow., which is characteristic of the Portland Stone, has been determined on the Ith, and also recently by myself on the Deister near Hanover, together with *Ammonites gigas,* in the Lower Portland.

b. The English *Portland Stone* has 23 species of animal fossils in common with the Hanoverian Upper Jura, but the distribution of these within the different zones is very different near Hanover. Only the following 7 species occur in the Portland formations generally: *Ostrea multiformis,** *Perna Bouchardi,** *Cyrena rugosa,** *Pleuromya tellina,** *Neritoma sinuosa, Ammonites giganteus* and *Serpula coacervata.* Of these the species marked with an asterisk have been observed in the Eimbeckhäuser Plattenkalke; the two others only in the beds with *Ammonites gigas.*

Sixteen species, on the other hand, occur only in older deposits than the Portland. Further, it is noteworthy that the Hanoverian Kimmeridge contains all the species in common with the Portland Stone, with the single exception of *Ammonites giganteus.* Of the 16 species which, according to existing observations, occur only in older beds, the following 13 species have hitherto been found near Hanover, *exclusively* in the Kimmeridge:—*Trigonia Micheloti, Lucina portlandica,** *Lucina plebeia, Corbicella Moræana, Sowerbya Dukei,** *Nerita transversa, Natica turbiniformis, Natica Marcousana,** *Cerithium trinodule, Cerithium Boidini, Cerithium Bouchardi, Pteroceras Oceani,* and *Serpula quinquangularis.*

With the exception of *Lucina plebeia,* however, these species have hitherto been found only in the English Portland Stone; those marked with an asterisk are even usually regarded as characteristic of the Upper Portland in England, and this applies also to *Cyrena rugosa* and *Neritoma sinuosa,* which in Hanover extend up through the *whole of the Kimmeridge* to the Portland. This is the best proof how little dependence is to be placed upon so-called characteristic fossils. To judge correctly of the age of beds, the conditions of stratification are above all things to be kept in mind; then the general character of the fauna is to be estimated, but at the same time the different phases of development in different districts must be taken into account. The small number of the corresponding organic remains in the English and North-German Portland formations.

cannot, therefore, considering their analogous conditions of stratification, present any hindrance to our regarding them as contemporaneous deposits. In North Germany I have distinguished only two subdivisions of the Portland,—the beds with *Ammonites gigas*, and the Eimbeckhäuser Plattenkalke; but if the so-called Münder Mergel, which marks the transition to the Purbeck, ought also to be referred to the Portland, and not to the Purbeck (a point which I leave for the present undecided), we should have to distinguish three zones in Hanover, just as in the Haute-Marne and near Boulogne. If in England, contrary to what occurs in France, only two great subdivisions can be distinguished, I regard this as an accidental circumstance of quite subordinate importance, which certainly does not justify the assumption that the lower part of the French Portland formations was not deposited contemporaneously with the English Portland, but with the Upper beds of the English

Principal Groups of the Wealden and Upper Jurassic.	Divisions in Engladn.	Divisions in Hanover.
Wealden.	*a.* Weald Clay. *b.* Hastings beds. *c.* Purbeck beds.	*a.* Weald Clay or Upper Wealden. *b.* Hastings Sandstone or Middle Wealden. *c.* Purbeck (Serpulite) or Lower Wealden.
Portland.	Portland Stone. Portland Sand.	Münder-Mergel as transition between Purbeck and Portland. Eimbeckhäuser Plattenkalke. Beds with *Ammonites gigas*.
Kimmeridge.	*a.* Upper Kimmeridge Clay. *b.* Lower Kimmeridge Clay. *c.* Kimmeridge Passage-beds.	*a.* Upper Kimmeridge or *Virgula*-beds. *b.* Middle Kimmeridge or *Pteroceras*-beds. *c.* Lower Kimmeridge (Astartian), *i.e. Nerinæa*-beds and zone of *Terebratula humeralis*.
Coralline Oolite (Corallian or Beds with *Cidaris florigemma*).	*a.* Supra-coralline beds (Upper Calcareous Grit). *b.* Coral Rag, Coralline Oolite and Middle Calcareous Grit.	*a.* Upper Coralline Oolite (zone of *Pecten varians*). *b.* Lower Coralline Oolite (zone of *Ostrea rastellaris* and Coral-bed).
Oxford Group.	*a.* Lower Limestone and Lower Calcareous Grit. *b.* Upper region of the Oxford Clay, with *Ammonites cordatus* and *Ostrea dilatata*.	Hersumer Beds.
Kelloway Group of the Middle Jura.	Then follow:— *a.* Zone of *Ammonites Jason*. *b.* Zone of *Ammonites macrocephalus*.	*a.* *Ornatus*-clays. *b.* *Macrocephalus*-beds.

Kimmeridge. But neither is it admissible or necessary to assume the existence of a gap between the English Upper Kimmeridge and the Portland Sand, seeing that, in my opinion, we need not have the least hesitation about regarding the Portland Sand and Portland Stone, taken together, as the equivalent of the three zones of the French Portlandian. The splitting up of the great divisions into distinct zones will in most cases only possess a local interest; on the other hand, it seemed to me to be of some importance to adduce the proof that the English and North-German Upper Jurassic formations in general admit of a uniform classification throughout. Finally (on page 556), is given a summary of the results arrived at.

IV.—THE INTERNATIONAL GEOLOGICAL CONGRESS, BOLOGNA, 1881.

By WM. TOPLEY, F.G.S.;
of H.M. Geological Survey of England and Wales;
Secretary of the English Committee on Geological Maps; and one of the Secretaries of the Congress.

THE International Geological Congress had its origin at Philadelphia in 1876, when, largely by the influence of Prof. Jas. Hall and Dr. Sterry Hunt, arrangements were made for a meeting of the Congress at Paris. This was held during the months of August and September, 1878, as one of a great series of International Congresses, embracing all branches of Science and the technical applications of the same. The full reports of these meetings are contained in 32 8vo. volumes; that on Geology forming No. 21 of the Series. In the Geological Congress papers were read and discussed on numerous subjects connected with the science. In view of the Second Congress, fixed for 1881 at Bologna, certain geologists were nominated as Presidents of the Committees in various countries, with instructions to form such Committees as they might think best, and to prepare Reports on the subjects requiring attention. These questions are classed in three divisions:—1. The Unification of Geological Nomenclature. 2. The Unification of Colours, Figures, etc., employed in Geological Maps. 3. Nomenclature of Species. Of the first, Prof. T. McK. Hughes is President for England. This Committee has been long at work; it has had several meetings in London, and has discussed and reported upon the signification to be given to numerous terms in common use amongst geologists. But besides this it has done much work, by means of sub-committees, in reporting upon the Classification, Nomenclature, etc., of the various groups of rocks hitherto spoken of as formations." In this respect the work of the English Committee is much in advance of that of other countries.

The Second English Committee, that on Geological Maps, has Prof. A. C. Ramsay for its President. Several meetings were held in London during the past summer, and the general results of the work were submitted to the Geological Section of the British Association at York.

Upon the third subject (Nomenclature of Species) nothing has been done in England.

The meeting of the Second Congress commenced at Bologna on

September 26th, under the presidency of Prof. G. Capellini. About 200 geologists were present, those from Italy and France of course largely preponderating. Although the number from various nations were exceedingly disproportionate, yet the International nature of the Congress is sufficiently apparent from the following list, in which the members are classified according to the countries to which they belong:—Austria 4, Belgium 6, Canada 1, Denmark 1, Egypt 1, France 17, Germany 6, Great Britain 5, Hungary 5, India 1, Italy 130, Portugal 2, Roumania 1, Russia 6, Scandinavia 1, Spain 4, Switzerland 8, United States 1.

As full reports of the proceedings will be hereafter published, it may suffice here to give a brief summary of the results. Two sittings were devoted to the discussion of Nomenclature, etc. The Reports and recommendations of the various National Committees had been summarized by Prof. Dewalque, who had drawn up a general Report (embodying these results) in a series of propositions, on which the votes were taken. The final result of the discussions was the adoption of terms in the following order, the most comprehensive being placed first:—

Divisions of sedimentary formations.	*Corresponding chronological terms.*
Group.	Era.
System.	Period.
Series.	Epoch.
Stage.	Age.

As equivalents of *Series*, the terms *Section* or *Abtheilung* may be used; as a subdivision of stage, the words *Beds* or *Assise*.

According to this scheme, we would speak of the Palæozoic Group or Era, the Silurian System or Period, the Ludlow Series or Epoch, and the Aymestry Stage or Age. The term "formation" raised a difficulty, because this word is used by English geologists in a sense unknown abroad. To bring our nomenclature into conformity with that of other nations, it will be necessary to use the word only as descriptive of the mode of formation, or of the material composing the rock. We may speak of the "Carboniferous Formation," as a group of beds containing coal; but not as a name for a set of rocks apart from the mineral contents. In like manner, we may speak of the "Chalk Formation" but not of the "Cretaceous Formation."

Two sittings of the Congress were given to the questions concerning the colours, signs, etc., best adapted for Geological Maps, with the view of obtaining greater uniformity in this matter than hitherto. On this subject a general Report had been drawn up, by Prof. Renevier, from the reports of the various National Committees. The scheme of colours as finally adopted is as follows:—

Groups or Systems.	*Colours.*
Crystalline Schists of Pre-Cambrian Age ...	Bright rose-carmine.
,, ,, Unknown Age	Pale rose-carmine.
Palæozoic rocks	(Question reserved for Map Committee.)
Trias	Violet.
Lias	Dark Blue.
Jurassic	Blue.
Cretaceous	Green.
Tertiary.	Shades of Yellow, the newer divisions to be in lighter tints.

The recommendations as to subdivisions, signs, etc., are nearly the same as those of the English Committee, which indeed were mainly founded upon those drawn up by Prof. Renevier; so that on these questions at least there is complete unanimity.

The proposal of the Congress to prepare and publish a Geological Map of Europe has met with universal approval, and especial prominence was given to this subject. A Commission was appointed, consisting of the President, Vice-Presidents (representing all countries), and a few other members, to report upon the best means of carrying out this work. Of this Commission Prof. Dewalque was Secretary, and he has just published the reports of its meetings, which were submitted to and adopted by the Congress. Stated briefly, the main results are as follows:—The work will be carried out by a Committee of eight members:—for Austro-Hungary, Dr. E. Mojsisovics; France, Prof. Daubrée; Germany, Dr. E. Beyrich (Director), and W. Hauchecorne (Assistant-Director); Great Britain, W. Topley; Italy, F. Giordano; Russia, Prof. De Moeller; Switzerland, Prof. Renevier (Secretary). Countries not directly represented on the Committee will be arranged for at a later date; but Austria will at once take charge of Turkey. Parts of Asia and Africa come within the Map; of these France will supply the material for Algeria; Great Britain that for Palestine, for which purpose it is hoped that the information collected by the Palestine Exploration Fund may be available.

The scale of the Map is fixed at 1 : 1,500,000, or about 25 miles to one inch. It will be published at Berlin; where the topographical map, which is to serve for its basis, is already in hand. The Map will be issued in sheets, which can be joined together as required. It is estimated that the cost will be about £2,500. To meet this expense application for assistance will be made to the various Governments of Europe. As the Map approaches completion, numerous questions will arise, concerning classification and similar subjects, which really belong to the Committee on geological nomenclature. A second Committee was therefore appointed, to co-operate with the Map Committee on these questions when necessary. This was formed for the most part from Vice-Presidents representing various countries. Prof. Hughes is the Member for England.

Much of the work connected with the Map will be done by correspondence; but meetings of the Committees will be held in September, 1882, at Foix, in the South of France, and in 1883 in Switzerland. The Map will be far advanced, if not completed, in time for the next meeting of the Congress, which is fixed for 1884, at Berlin, under the Presidency of Dr. E. Beyrich. The fourth meeting of the Congress will probably be held in England.

The foregoing is only a brief statement of results, and takes no note of many things which made the Congress so great a success and so pleasant a gathering. For these we have to thank those who have been working to this end for many months past; chief amongst them we must note Prof. Capellini, Professor of Geology at the ancient University of Bologna. and President of the Congress ; and M. F. Giardano, chief Mining Engineer and head of the Geological Survey of Italy.

NOTICES OF MEMOIRS.

INTERNATIONAL GEOLOGICAL CONGRESS.

FINAL RECOMMENDATIONS OF THE ENGLISH COMMITTEE FOR REPORTING UPON THE COLOURS, SIGNS, ETC., EMPLOYED ON GEOLOGICAL MAPS. (Presented to the International Geological Congress at Bologna, September 26, 1881).[1]

1. For general maps of large areas, and for small-scale maps of individual countries, it is desirable to frame some scale of colours which can be readily used and easily understood by all nations.

2. For sedimentary rocks a scale of colours, based on the order of colours of the solar spectrum, is desirable for such small or general maps ; subject to such modification as may appear necessary.

3. The scale of Colours recommended is :

Pleistocene	Burnt Sienna.
Pliocene	Buff.
Miocene	Orange.
Eocene	Pure Yellow.
Cretaceous	Green.
Jurassic	Blue.
(Lias	Indigo.)
Trias	Venetian Red.
Permian	Chalons Brown.
Carboniferous	Dark Grey, distinguishing limestone by a wash of blue.
Devonian	Indian Red.
Silurian	Violet.
Cambrian	Purplish Violet.
Pre-Cambrian	Purplish Carmine.

4. Sub-divisions of Formations.—Three or four shades of the body-colour to be used ; the darkest shade for the lowest or oldest sub-division. Dots, lines and white spaces to be used where necessary. Where lines or dots are used, they should, if possible, be the same as the body-colour but a darker shade. It was suggested that if possible such lines should run from N.W. to S.E. of the map.

4*a*. Freshwater formations should be distinguished by some method. Coloured lines or engraved signs were suggested.

5. Metamorphic rocks to be marked, as such, by dark bands of colour, the same as denoting the age, but a darker shade. When the age of the metamorphism is known, the fact may be denoted by additional bands of colour of the age of the metamorphism. Thus : Cambrian rocks altered in Cretaceous times would be purplish-violet, striped with alternate lines of dark purplish-violet and green.

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[1] The resolutions passed by the Congress at Bologna differ from those adopted by the English Committee chiefly in the following particulars :—

3. The scale of colours for the Map of Europe is modified as stated above. The colours for Palæozoic rocks being left undecided for the present.

4*a* and 6 were not considered. 5 only so far as to define the colours to be used for crystalline schists of Pre-Cambrian or of unknown age.

6. Igneous Rocks.—Four colours would suffice. All colours to be bright, deep and glossy—

Basalt and Greenstone	Dark Carmine.
Trachyte, Felstone, etc.	Permanent Scarlet.
Granite	Vermilion.
Modern Volcanic Rock	Light Orange.

7. The letter-notation of the formations should be based upon the Roman alphabet for sedimentary rocks, and upon the Greek alphabet for eruptive rocks. The monogram of a formation should be formed, as a rule, by the Initial Capital of the name of that formation; the subdivisions to be distinguished in addition to this Initial Capital, by the initial small letter of the name of the subdivision, by a numerical exponent or by both. The figures of the numerical exponents to be always given in chronological order,—1 representing the first or oldest subdivision. Example:

J. Jurassic.
Jl Lias,
Jl^2 Middle Lias.

8. This Committee approves of the proposal to issue a Geological Atlas of Europe, under the authority of the Congress.

Signed, A. C. Ramsay, President of the Committee.
W. Topley, Secretary.

REVIEWS.

I.—Volcanoes: What they are, and What they Teach. By John W. Judd, F.R.S., Professor of Geology in the Royal School of Mines. 8vo. pp. 382. With 96 Illustrations. (London: C. Kegan Paul & Co., 1881.)

THE book before us possesses a twofold interest: firstly, as the work of an ardent and rising geologist who has been favoured with peculiar advantages, both of education and opportunity, for the study of volcanic phenomena; and, secondly, as having been written at the inspiration of the most accomplished exponent of Vulcanology in this country, the late Mr. G. Poulett-Scrope. If his venerated friend and master in Geology could have been spared to enjoy one additional pleasure before he passed away, nothing, we feel sure, could have enhanced his happiness more than to have lived to see the issue of the present volume by his friend and disciple Prof. Judd. Certainly, in Mr. Poulett-Scrope's case, the dictum of Mark Antony must be reversed, and we may indeed say of him, "The good he did lives after him."

It is only within the last hundred years that any rational or intelligible views with regard to volcanos are to be found. Previous to that time they were looked upon as "burning mountains," or as the abode of some deity, or as the place of torment of some special and heinous offender.

To the early Greeks and Romans the crater of Ætna marked the spot where Typhon, the hundred-headed monster, lies buried, and where Vulcan, surrounded by his Cyclopes, forged the thunderbolts of *Zeus*.

To the Pacific Islander's simple mind the crater of Kilauéa in Hawaii is the dwelling of the goddess *Pélé*. In Java, the fury of its volcanos has led to the dedication of the island to *Siva*, the god of destruction, and in the very craters of these burning mountains the worshippers of Terror and Death were in the habit of erecting their temples.

So, also, the ever-smoking orifice of Tongariro in New Zealand was considered by the Maoris as the only place worthy of receiving the dead bodies of their chiefs; for, when cast into the crater, they went to sleep among the gods.

To the untutored savage and to the ignorant bigot, alike, the subterranean roarings and the thundering eruptions of vulcanos implied a demand for human sacrifice to appease the residing deity. Acting under the influence of fear and ferocity, the priests of not a few religions have cast victims with great pomp into the gaping mouths of these immense furnaces.

Scarcely three centuries ago, when the early disciples of Christianity were exterminated over the whole island of Japan, the followers of the new religion were thrown by hundreds into one of the craters of the Unsen, perhaps the most beautiful volcano in the Archipelago.

Both in the old and new world the priests of the Romish Church have deemed such volcanic outbursts as emanations of the Evil One, and have never ceased to conjure the restless and unquiet spirits of the nether world to cease their troubling.

Even in our own day, if we no longer look upon these phenomena as belonging to the supernatural, still we are too apt to regard them as altogether different from other facts of terrestrial vitality.

The first effort at a better comprehension of the phenomena of volcanos was made in 1788 by the illustrious Italian naturalist Spallanzani, who visited and published an account of the volcanos of his native land. The French geologist Dolomieu added observations on volcanic ejecta; our own countryman Sir William Hamilton, Ambassador to the Court of Naples in 1764, devoted much time, during his long residence of thirty-six years at that court, to careful observations of Vesuvius and the neighbouring volcanos, the results of which he published in his celebrated work, entitled "Campi Phlegræi," accompanied by most excellent illustrations of the places and phenomena which he saw. To these early writers we must not omit to add the names of those three most famous German naturalists, Von Buch, Humboldt, and Abich, who greatly extended our knowledge of volcanos by their travels in different portions of the globe.

"But the first attempt to frame a satisfactory theory of volcanic action, and to show the part which volcanoes have played in the past history of our globe, together with their place in the present economy, was made in 1825, by Poulett-Scrope, whose great work 'Considerations on Volcanoes,' may be regarded as the earliest systematic treatise on Vulcanology. Since the publication of this work, many new lines of inquiry have been opened up in connexion with the subject, and fresh methods of research have been devised and applied to it. More exact observations of travellers over wide areas have greatly multiplied the facts upon which we may reason and speculate, and many erroneous hypotheses which had grown up in connexion with the subject have been removed by patient and critical inquiry."

From the days of Spallanzani to our own, all the real additions to our knowledge of Vulcanology have resulted from long and patient observations of actual volcanos, both in their active and quiescent states, and by a careful chemical and microscopical study of the minerals they have ejected upon the surface.

Gases, and especially steam, in a highly-heated state, are unquestionably the great motor agents in all volcanic displays, and to their larger supply and greater compression is doubtless due the intensity and duration of each eruption.

The presence of water is not caused (as many have supposed) by the sea finding its way by fissures and cracks into the earth's heated interior, and so, by being suddenly converted into steam, giving rise to those subterranean convulsions of which earthquakes and volcanos are the concomitant indications. On the contrary, it appears, both from observations and experiments, that not only vast quantities of aqueous vapour, but also enormous volumes of various gases, are interstitially present *everywhere* in the earth's crust. The rocks composing it, upon being liquefied, under enormous heat and pressure, have the power to absorb many times their own volume of certain gases as well as water-gas. That such is the case we have indisputable evidence in the prodigious quantities of both gases and steam given off during volcanic outbursts and while lava-streams are flowing. Even the volcanic materials of past ages, " which have been consolidated under great pressure, such as granites, gabbros, porphyries, etc., exhibit in their crystals innumerable cavities containing similar gases in a liquefied state. It is to the violent escape of these gases from the molten rock-masses, as the pressure upon them is relieved, that nearly all the active phenomena of volcanoes must be referred; and it was the recognition of this fact by Spallanzani, while he was watching the phenomena displayed in the crater of Stromboli, which laid the foundation of the science of Vulcanology." (p. 357.)

There is one interesting point dwelt upon by the author in connexion with volcanic phenomena which cannot be omitted. It is the fact that up to the present time, notwithstanding the now considerable number of substances known to occur in meteorites, no element has yet been found in any meteorite which was not previously known as existing in the earth; and out of the sixty-five or seventy known terrestrial elements, no less than twenty-two have already been detected in meteorites. But as there are a dozen elements which occur in overwhelming proportions in the earth's crust, viz. oxygen, silicon, aluminium, calcium, magnesium, sodium, potassium, iron, carbon, hydrogen, sulphur, and chlorine, making up amongst them not less than 999 out of 1,000 parts of the earth's crust, and all of these twelve common terrestrial elements occur in meteorites, we see how closely these small bodies unite us to the other heavenly bodies around.

One fact, however, the author points out, of great importance, namely, that the way in which these elements occur in meteorites differs materially from their mode of occurrence on our earth's crust, as if the circumstances surrounding their union were very unlike those of our earth's surface. We have, for instance, *Meteorites* (called *Holosiderites*) which are masses almost wholly composed of metallic iron or of iron alloyed with nickel—others (*Syssiderites*) formed of a network of iron inclosing stony materials—others (*Sporadosiderites*) of stony material with particles of metallic iron disseminated through it—and lastly *Asiderites*, which contain no metallic iron, but consist entirely of stony materials.

The stony materials of these (*Asiderites*) have been matched by certain ultra-basic rocks which have clearly been carried up with the other lavas from great depths in the earth's crust. Nodules composed of the same minerals which are so highly characteristic of meteorites occur in basaltic lavas and tuffs and also in the centres of volcanic bombs which are thrown out of craters during eruptions.

Lastly, and still more interesting, is the discovery that materials similar to the metallic portion of meteorites, and consisting of nickeliferous iron, also occur in deep-seated portions of the earth's crust, and have been brought to the surface during periods of igneous activity.

Large blocks of iron like ordinary metallic meteorites (being composed of iron alloyed with nickel and cobalt) were found in 1870 by Prof. Nordenskiöld at Ovifak, Disko Island, off the coast of Greenland (see GEOL. MAG. 1872, Vol. IX. p. 462, etc.). These were at once concluded to be a number of meteorites which at some past time had fallen upon the earth's surface.

But a further examination of the locality showed that the rocks composing the basaltic dykes adjacent to the iron-masses were *full of particles of metallic iron!*

Thus another link is added to the wondrous chain by which our earth is united to other and distant worlds; planet to planet, and star to star; binding the whole material universe together by the law of Continuity.

Turning from our earth to the sun, we see in its brilliant prominences evidence of a volcanic energy far surpassing in grandeur anything of which we can form an idea, yet there can be no doubt that its surface is but a highly accelerated and immensely magnified repetition of what goes on in the pigmy volcanos on our earth.

Our own satellite presents us with the obverse of the sun's busy energy. In the moon we see the condition to which a planet may be reduced in which all cosmical energy has died out, because the motive power of that energy (its atmosphere and ocean) no longer exists. It is, as our American cousins would say, "played out."

"Terrible and striking, then, as are the phenomena connected with volcanic action, such sudden and violent manifestations of the subterranean energy must not be regarded as the only, or indeed the chief, effects which they produce. The internal forces continually at work within the earth's crust perform a series of most important functions in connexion with the economy of the globe, and were the action of these forces to die out, our planet would soon cease to be fit for the habitation of living beings" (p. 302).

It would be impossible to give an adequate notice of Prof. Judd's admirable work in our limited space. Fortunately, however, the book is so planned, both for size and price, as to bring it within the reach of every student of Geology; and every student should possess a copy.

In conclusion, our readers may be reminded that some of the earliest and *most valuable* of Prof. Judd's studies of Volcanos in Italy and Hungary appeared as ORIGINAL CONTRIBUTIONS to the pages of this MAGAZINE for 1875, pp. 1, 56, 145, 206, 245, 298, 348, 388, 482, and 1876, pp. 5, 53, 200, 337, 487, 523, 529.

II.—THE GEOLOGY OF THE NEIGHBOURHOOD OF CAMBRIDGE. By W. H. PENNING and A. J. JUKES-BROWNE. Memoirs of the Geological Survey of England and Wales. 8vo. pp. 184. (London, 1881.)

THAT a Memoir of the Geological Survey of the size above indicated, and accompanied by twenty-three woodcuts, three plates of fossils, two coloured maps, and two plates of sections, should be published at 4*s*. 6*d*., is such a marked improvement in the price of Survey publications, that we feel bound to call attention at once to this great reduction in cost, which we hope may be maintained in the future.

The Memoir now before us is an explanation of Quarter-sheet 51 S.W., with part of 51 N.W., of the Geological Survey Map, and although it will not compare in point of scope or popular interest with Professor Bonney's Geology of Cambridgeshire, it furnishes a detailed account of the geological facts connected with a portion of the county which cannot fail to be of scientific as well as practical value. The formations described include the Oxford Clay, Kimmeridge Clay, Lower Greensand, Gault, Chalk, Glacial and Post-Glacial Drift. In their account of the Chalk the authors have added much to what was previously known, and their labours lead them to feel confident in the existence of zones in the Chalk, and that these are remarkably constant throughout the whole extent of the escarpment from Dorsetshire to Cambridgeshire. In this respect they corroborate and supplement the work of Dr. Barrois. Further, in the larger divisions under which the zones may be grouped, they apply the general classification proposed in 1833 by Samuel Woodward for the Chalk of Norfolk, thus making Upper, Middle (or Medial), and Lower divisions.

A general account of the palæontology of the different subdivisions of the Chalk forms the subject of an Appendix by Mr. Etheridge, who also describes and figures a number of new species of Mollusca. The "Cambridge Greensand," with its included erratics and coprolites, is treated of under the heading of Chalk Marl, and some account of the origin of the phosphatic nodules is given. The origin of the flints of the Upper Chalk is also briefly discussed, the authors attempting to account for the occurrence of flints in regular layers, by considering that an "initial plane of segregation" was given at repeated intervals by organic remains strewn over the surface of the chalk mud; and that the silica, which at first was equally distributed throughout the water by which the unsolidified portions of the mass was permeated, accumulated along the same plane of decaying organisms, notwithstanding the mud that was still being thrown down, and by which the forming line of flint was buried. They "assume that the force, whatever it may have been, would act upwards and downwards through some definite thickness of the mud, and that until the sediment had attained a certain height above such line, the silica would continue to segregate along it, in and around its organisms. When that point was reached no more silica would segregate along that particular zone, the organic remains on the then existing floor would in a similar manner serve as the nuclei of a new layer, and another line of flints would be at once commenced." This explanation is suggestive, although it leaves much to be said, before the subject can be said to be plain and easily understood.

The description of the Glacial Drift occupies but a few pages; it comprises Boulder-clay, Marine Gravels and Loam. In a subsequent chapter the authors enter at some length into the question of the physical conditions under which the Glacial and Post-Glacial Drifts were deposited; and they express their conviction that the Boulder-clay was mainly produced by the action of Coast-ice.

The various Post-Glacial gravels are described in much detail, and a map is given to show the courses of the Ancient and Modern Rivers in Cambridgeshire.

The lists of fossils from the various formations and localities are very full. Details of well-sections and borings are given; and there is also a list of works on the Geology of Cambridgeshire, compiled by Mr. Whitaker, who superintended the field-work and has edited the Memoir.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 2, 1881.—R. Etheridge, Esq., F.R.S., President, in the Chair.

Prof. Hughes called the attention of the Society to the work being done by the Swiss Palæontographical Society. He pointed out that, the Swiss being a small nation, and their scientific men proportionately few in number, it was a very spirited thing of them to keep up the regular publication of a series of exhaustive treatises on the plan of our own Palæontographical Memoirs. Those engaged in palæontological work knew well the value of these publications, and could appreciate the labour and care necessary to keep going such a large undertaking. He felt sure that much more support could and would be offered to our Swiss fellow-labourers and our good friend Renevier, if the English public could be made aware of the important work they were doing. He therefore invited the co-operation of the members of the Society in the matter.

The President announced that at the next meeting of the Society Prof. Hughes would state what were the general results achieved by the International Geological Congress held this year at Bologna.[1]

The following communications were read :—

1. "On the Genus *Stoliczkaria*, Dunc., and its Distinctness from *Parkeria*, Carp. and Brady." By Prof. P. Martin Duncan, F.R.S.

The author discussed in detail the characters of his Syringosphæridæ, a group of Rhizopoda established by him for the reception of the spheroidal organisms known in India as Karakoram stones.

The order Syringosphæridæ consists of spherical or spheroidal bodies composed of numbers of conical radiating congeries of minute, continuous, long, bifurcating, and inosculating tubes, and of an interradial tube-reticulation arising from and surrounding the radial congeries. The tubes open at the surface in eminences and in pores. The walls of the tubes consist of granular and subspiculate carbonate of lime. There is no cœnenchyma. In *Syringosphæria* (fully characterized by the author in "Scientific Results of the Yarkand Mission," Calcutta, 1879, p. 10) the body is covered with large compound wart-like prominences with intermediate verrucosities, or with modifications of such structures, and between these eminences are shallow depressions bounded by tubes. The surface has tubes opening upon it from the internal radial series and also from the interradial reticulation ; there are also masses of tubes running over it and converging on the eminences. In *Stoliczkaria*, a second genus, the surface is covered by numerous granulations, separated by intervals about equal to their breadth. There are no pores on the surface, but tube-openings occur in the granulations. The central ones, which are small, are the terminations of the very numerous radial series, which, in section, are not very conical but nearly straight, and give off minute offshoots to the surrounding convoluted and varicose larger tubes of the interradial series, which open towards the periphery of the granulations. There is no cœnenchyma. The species is named *Stoliczkaria granulata*.

He then proceeded to compare the structure of the Syringosphæridæ with that of *Parkeria*, with which they have a considerable resemblance in external appearance. The internal structure differs. *Parkeria* shows a radial series of large tubes, a system of interspaces in concentric series, and a labyrinthic structure of irregularly-shaped chamberlets, communicating with each other and cancellous in appearance. The interspaces are traversed by one or

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[1] This is given by Mr. Topley, see ante pp. 557-561.

more large radial tubes, and the floor of each interspace towards the centre is made up of the minute chamberlet structure, the openings of which communicate only with the interspace beyond. The labyrinthic structure sometimes stretches across the interspaces, and the radial tubes communicate at their sides with the labyrinthic chamberlets of the lamellæ forming the floor and roof of the interspaces. The continuity from the centre of the body to the circumference is thus defective, and the body consists of radial tubes and of a labyrinthic structure of a cellular and semicellular character.

The author maintained that the two structures were intrinsically different, and he also indicated a difference in the mineral condition of the fossils, *Parkeria* being always phosphatic, whereas no phosphate of lime could be detected in *Stoliczkaria*.

2. "On the Elasticity- and Strength-constants of Japanese Rocks." By Thomas Gray, Esq., B.Sc., F.R.S.E., and John Milne, Esq., F.G.S.

In this paper the authors described the results of some experiments made to determine the elasticity-constants and strength against rupture and crushing of a few of the commoner Japanese rocks, their chief object being to obtain data for calculating the theoretical velocities of earthquake-wave transmission. The rocks submitted to experiment were a grey granite, a pure white crystalline marble, a greyish-green soft tuff, a mottled clay-rock, and clay-slate.

Young's moduli were determined by the bending of solid cylinders of the rocks in an apparatus described and figured; the deviations produced were read by means of the reflection from a mirror, which magnified them more than 200 times. The process for determining the rigidity was also described and illustrated by a figure; and the experiments in crushing were made upon columns of stone by means of a Bramah press. In experiments on the rupture of the columns there was no marked deviation from the proportionality of strain to stress up to the breaking-point, except in the case of the marble. In crushing, the authors obtained considerable lower moduli than those quoted in tables for similar rocks; and, as their experiments were performed upon columns about three times as long as their diameter, they repeated them upon columns of marble varying in length from one half to six times the thickness. The results seemed to show that the short specimens were the weakest; but there was little difference. The authors give the formulæ by which they worked out the results of each series of experiments, and bring together the mean results in a tabular form.

3. "The Glacial Deposits of West Cumberland." By J. D. Kendall, Esq., C.E., F.G.S.

The author gave a brief sketch of the physical geography of the district and of the distribution of the more remarkable and easily recognized varieties of rock. The glacial deposits, viz. Boulder-clays, sands, and gravels, occupy mainly the area of low ground skirting the hills, extending upwards to a height of about 500 feet above the sea; above that contour-line they only occur in isolated patches or tongue-like prolongations up valleys to elevations occasionally of about 1,000 feet. The deposits, where fully developed, consist of Upper Boulder-clay, Middle Sand and Gravel and Lower Boulder-clay; together they sometimes attain a thickness of from 100 to about 130 feet. Certain peculiarities in the distribution of the deposits were described. The tripartite arrangement never occurs in the valleys in the mountainous district. Boulder-clays, indeed, sometimes occur here, but sands are more common. The distribution of the boulders from the more remarkable rocks was described; tables of these were given, as also of the maximum height above the sea at which each occurs. The origin of the deposits was next discussed. The author is of opinion that the presence in the Lower Boulder-clay of boulders derived from such widely different sources can only be explained by floating ice, but that the correspondence of the materials of the clay with rocks in the vicinity shows that glacier-mud produced the finer elements. The Middle Sand and Gravel he considers due to denudation of the above materials during a period of emergence. The Upper Boulder-clay he attributes to a second period of submergence corresponding generally in its conditions with the former one. The gravel mounds are probably caused by the stranding of bergs at the end of this period.

CORRESPONDENCE.

THE SUDDEN EXTINCTION OF THE MAMMOTH.

Sir,—I was flattered by finding two communications in the last Number of your Magazine devoted to the papers I have, by your favour, printed in that most catholic of geological publications. It is some proof, at all events, that the papers have attracted notice. With one of these communications, signed Ignoramus, I most completely agree. There is no pedantry more transparently foolish than that which dots its pages with quotations in a foreign tongue. In my case, the excuse is that I was writing as a heretic, upon a question in which a large proportion of English geologists are ranged on the other side, and therefore in quoting critical and important passages, to avoid all pretence that I was garbling or introducing my own personal equation into my authorities, I thought it better to give the exact words of the author. I will not transgress the same way again; but if I have occasion to quote, I will give the most faithful translation I can command. To Mr. Reid I must devote a larger space. First, let me thank him cordially for the terms in which he has spoken of my papers. It is a great point gained to have no quarrel about the facts, which are therefore at the disposal of all your readers. Nor is there any quarrel about the cardinal postulate upon which my view is based, and which is shared by Mr. Reid, if I understand his letter rightly, with the Russian geologists, namely, that the Mammoth lived and died where his remains are found.

Mr. Reid says the conclusions I have drawn are *quite* unwarranted by the facts. This is merely a strong phrase to use of conclusions arrived at by such profound teachers of physical science as Cuvier and Buckland in the last generation, and d'Archiac in this. The phrase, however, may pass as meaning merely that Mr. Reid himself does not agree with these conclusions. He also speaks of the view which is opposed to the current Uniformitarian theory as an extinct theory. Surely again Mr. Reid limits his language to the scholars of Lyell in this country. He cannot have read what the great school of geologists in France and Belgium, where so much work has been devoted to Post-Glacial deposits, has written and is writing upon the question of Uniformity, or he would not use the term extinct theory to the view maintained by its opponents.

These phrases are, however, mere prejudice. We are not theologians discussing authority, but students of an inductive science in which the facts are the things to appeal to, and not the name of this or that writer—of this or that popular school of geology. If I have quoted others, it is only to show that what I have advanced has been held by bigger men than myself. Let us then to the facts. Those who hold Mr. Reid's view have to account for two things—the presence of Mammoth remains buried in elevated clay-hills throughout the length of Siberia; and, secondly, the preservation of the flesh of these Mammoths fresh and intact. In regard to the former difficulty, Mr. Reid suggests that the Mammoths were buried by sediment from the Siberian rivers. It is true that the upper reaches of the River Obi, where, by the way, Mammoth remains are infrequent, are subject to very wide floods, caused by the stoppage of the drainage by the mouth of the river being hard frozen, while its sources are thawed; but this is by no means the rule with the other Siberian rivers, especially those of Eastern Siberia, where the Mammoths abound, and which have deep channels and steep banks. There floods are comparatively slight, nor do such floods reach the high ground where the Mammoths are chiefly found, nor is the high ground composed of river sediment, but largely of clay. The floods seen in the lower Tundras are not fluviatile, but caused by the melting of the summer snow on their surface. Again, as I have quoted from Schmidt, who is the most experienced geologist who has examined the problem on the spot, the Siberian rivers do not deposit sediment that could envelope the Mammoths. Lastly, the fluviatile theory requires that the Tundra throughout Northern Siberia should be submerged entirely throughout the winter months; for unless the high ground is covered, the problem is not solved. If so, how could the Mammoths live there at all? Even Dr. Tanner, with his aqueous tastes, would be puzzled to live a few months upon the frozen beverage which North Siberia supplies so plentifully, much less great pachyderms requiring immense stores of vegetable food daily.

Mr. Reid speaks of the occasional preservation of carcases of Mammoths and Rhinoceroses. Considering that they are found in the whole breadth of Asia from the estuary of the Obi to Behrings Straits, in a region almost deserted by civilized man, and therefore beyond the reach of anything but casual inquiry, and considering the number of recorded cases and the long ages during which their occurrence has been recorded, the word occasional seems misplaced. It seems in fact clear, from the frequency and dispersal of the carcases, that their occurrence is according to some law, and not according to mere local circumstance; for the conditions in which they are found are the same over 120 degrees of longitude.

Mr. Reid says the plants found with the Mammoth do not show a warm climate. As the same trees and the same land shells have been found with the Mammoth in Germany and in Northern Siberia, it shows a climate consistent with the possible climatic conditions of Germany in Post-Glacial times—a climate inconsistent altogether with permanently frozen ground close to the surface over a whole continent, or with winter conditions such as no large herbivores could contend with. The problem further requires that over the whole of Northern Asia the climate should once have been so temperate and mild that the bodies of the Mammoth, etc., could be thrust into the ground or covered with it, and that afterwards, and from the time they were so thrust in, that same ground must have remained hard frozen to our own day. On this condition only could the flesh be preserved. If this were a mere local matter affecting one small area, we might invoke local causes like the case of Mount Etna, but the case is a continental one. The Bear Islands, where no shrub can exist at all 150 miles away from the mouth of the Lena, the occasional home of the Arctic Fox and the Snowy Owl, must, when the Mammoth lived, have supplied an abundant vegetation even in winter; so must the whole of that terribly inclement district the Peninsula of the Chuktchi; so must the tundras from the Yenissei to the Lena; and yet immediately the animals died the ground must have been so frozen for several feet below the surface as to be impervious both to the sun's heat and to the filtration of water. I never urged that the state of things existing now at Yakutsk, where it is probable the ground is permanently frozen for 600 feet from the surface, was created suddenly. It is no doubt the result of many centuries of hard climatic conditions. The presence of beds of blue ice alternating with clay and soil, and due probably to some unexplained filtration of water, is no doubt also the result of a long process; but what I urge, and have always urged, and have had my opinion confirmed by the views of many scientific men with whom I have discussed the problem, is that the Mammoth, when alive, must have been surrounded with temperate conditions and abundant food, while directly after he died Arctic conditions must have at once supervened and prevented the decay of his body. The proofs of this position, which seems to me to be more impregnable with every fresh piece of evidence, are cumulative. I have tried to present a number of them as fairly as I could. As yet I have stated but half my case. However, I hope my good friend Dr. Woodward, who has been very considerate to my heresies, will allow me to present the remaining evidence, which is more purely geological. I must emphatically say that I very much distrust all deductive methods in science. The formulating of a very plausible plea of uniformity as an infallible dogma, and then reading one's facts up to it, is a misleading method. The only fertile method in such inquiries as ours is induction from the facts, and to this I most unflinchingly invite your readers.

If the facts are susceptible of a more reasonable explanation than that I have given, by all means let us have it, and I will surrender. At present I am a more incorrigible heretic than ever. I hope I have not said one offensive or irritating word. If I have, may it be cancelled and forgiven. In conclusion, let me quote a most weighty sentence or two from one whom both Mr. Reid and myself will agree with honouring and paying some deference to. Professor Huxley, in his address to the Geological Society for 1869, said, "To my mind there appears to be no sort of necessary theoretical antagonism between Catastrophism and Uniformitarianism. On the contrary, it is very conceivable that catastrophes may be part and parcel of uniformity. Let me illustrate my case by analogy. The working of a clock is a model of uniform action. Good time-keeping means uniformity of action. But the striking of the clock is essentially a catastrophe. The hammer might be made to blow up a barrel of gunpowder or turn on a deluge of water; and by proper arrangement the clock, instead of marking the hours, might strike at all sorts of irregular intervals, never twice alike in the intervals, force, or number of its blows. Nevertheless, all these irregular and apparently lawless catastrophes would be the result of an absolutely Uniformitarian action, and we might have two schools of clock theorists, one studying the hammer and the other the pendulum." These are weighty words, to every one of which I subscribe. In objecting to the current doctrine of Uniformity, it may be suggested that I am objecting to the government of the universe by law—a view I repudiate altogether. What I say is that the law which governs the universe is not to be grasped by those who will not look beyond what is passing now at their elbows. A beautiful city like Lisbon, where I was born, has existed for 100 years in peaceful prosperity; and yet in 1753 it was overwhelmed by the most terrible cataclysm that is mentioned in modern history. That cataclysm is the type of others. How can such an event, the only one of its extent and kind recorded in the West, be explained by the current school of English geologists? To Professor Huxley, and those who hold with him, such a cataclysm is as much the result of law as the peace which has succeeded; and to some of us a cataclysm of a much greater extent, involving a great revolution in current geological views about Post-Glacial geology, is just as reasonable a *priori*, while we affirm that it is abundantly required to explain the facts. HENRY H. HOWORTH.

DERBY HOUSE, ECCLES, *Nov. 5th*, 1881.

COAL-MEASURES UNDER THE NEW RED SANDSTONES.

SIR,—Permit me to say that the discovery of limestone bands at Winwick beneath the Trias is not quite so novel a one as both Mr. Strahan and Mr. De Rance appear to think.

In a letter of mine to the *Liverpool Daily Post*, dated 15 Sept.

1872, and afterwards copied into *Nature*, Sept. 19, 1872, the following passage occurs:—"But a well-boring at Winwick, after penetrating 150 feet of Red Sandstone, the upper part of which is placed with the pebble beds in the Geological Survey sheet, was sunk 210 feet through strata consisting of hard rock, stiff red marl, red and white sandstone, *with a zone of limestone bands* at the base, the boring terminating at 360 feet from the surface, in hard rock."

In this letter the possibility of finding workable coal under the Trias is fully discussed. I further observed that I "was inclined to think" that these beds "belong to the Permian rather than to the Upper Coal-measures." The borings through the Trias at St. Helen's have been made since this letter was written.

Park Corner, Blundellsands, T. Mellard Reade.
Nov. 9th, 1881.

DR. CALLAWAY'S VIEWS ON ANGLESEY GEOLOGY.

Sir,—At page 423 of the September Number of this Magazine, Dr. Callaway states, speaking of the Geology of Anglesey, "that *in no case* are there any signs of a transition between the altered and unaltered beds." It is not quite clear to what beds he refers as altered or metamorphic beds; but if he has in view, as I imagine he has, the great gnarled series of Anglesey, which occupies the whole northern part of the island, I venture to take serious exception to his statement. This area of so-called metamorphic rock is represented on the Survey Map as bounded on the south by a great curved fault. On the coast at Porth Corwg, near Point Ælianus, where the fault is represented as running out to sea, a fault undoubtedly does occur, and the gnarled beds are there seen to rest against the shales. As far as I know, this fault is actually seen nowhere else. It has been assumed to exist, as the most plausible explanation of the stratigraphy of the district, and has been so indicated on the map. There are various circumstances which suggest that the line laid down on the map is not the line a great fault would take, and I am in a position to state that no fault occurs at two points (at any rate) of the line indicated; for a distinct passage can be seen and traced inch by inch from the fossiliferous shales to the beds marked "altered Cambrian" on the Survey Map, and which Prof. Hughes calls the "gnarled series," This passage is shown on the slopes of the north side of Pare's Mountain, where bare rock crops out at the surface for some distance, and the character and texture of the rocks can be distinctly observed. Also at Hafod-onen, near Rhosgoch Station, where, on the bared surface of the farm-yard, the two series can be seen passing into one another, the one dipping under the other. I do not assert that fossiliferous Cambrian shales pass into metamorphic rocks, but I do assert that I have seen such shales pass into beds which Dr. Callaway has included under the head metamorphic. If the term metamorphic is used in any strict sense as implying a re-arrangement and crystallizing of mineral constituents, I do not see how it can be applied indiscriminately to the "gnarled series." Parts of the Llandovery beds of Central Wales are quite as metamorphic-looking as much of the "gnarled series" of Anglesey. We are presented in that island with as complicated a piece of geology as Great Britain can show, and no little field-work must be patiently prosecuted before the problems can be solved.

According to my view, Dr. Callaway has misapprehended some of the most important sections. In a short paper printed in this MAGAZINE last March, I pointed out that the Nebo sections described by him as unconformable junctions of "Ordovician shales" on granitoidite are really faulted junctions of shales against the basement bed of the Cambrian. This at Nebo is a very compact fine-grained grit, which Dr. Callaway has mistaken for granitoidite. At Bryngwallen quarry, near Llanerchymedd, a precisely similar grit may be seen passing down into a quartz conglomerate not distinguishable from that of Twt Hill, and passing up into a fossiliferous sandstone containing *Orthides*, the whole section included in some 30 or 40 feet. R. D. ROBERTS.

CLARE COLLEGE, CAMBRIDGE, *Nov*. 7, 1881.

THE "LOWER KEUPER SANDSTONE" OR "BASEMENT BEDS."

SIR,—While thanking Mr. Wilson for his support of much that I have said on these rocks, I must correct a slight misapprehension with regard to my views. I do not hold the "theory of a great break" at the base of the Waterstones attributed to me, but merely point to the recurrence of lines of erosion at this and other horizons in the Trias to show that they are no evidence of want of conformability; on p. 6 I use the words "though there is no unconformability," etc.

I do, however, believe that a great change of physical conditions commenced at this period, and that, judging by its effect upon the nature and distribution of the deposits, this was the most important change that took place in the British region during the Triassic era. For I consider the theory that the Bunter was upheaved into dry land and denuded, before the Keuper was deposited, far from being proved.

Mr. Wilson states that "At the close of the Bunter period elevation took place, in the Midlands certainly, if not generally throughout the country, accompanied by extensive and long-continued denudation." The evidence for this elevation and denudation consists in the fact that the Keuper Basement Beds rest on Pebble Beds near Nottingham, but on Lower Mottled Sandstone at four miles distance, the inference being that at least 200 feet must have been denuded away.

But it must be borne in mind that the Bunter deposits thin away to the south-east, as though deposited against a shelving shore, and that Nottingham stands on the margin of the area over which these shingles were originally spread. The inference therefore that the Pebble Beds must have been denuded away in those places where they are absent below the Keuper is unsafe, for they probably never extended so far. It is true that the disappearance of the Pebble

Beds takes place somewhat rapidly, but this is noticeable all along their south-easterly margin, and "conglomerates and coarse conglomeratic sandstones are notoriously local formations, suddenly swelling out into great masses, and as rapidly dwindling down again, or disappearing altogether," as Prof. Geikie remarks (Old Red Sandstone of Western Europe). I think also that the irregularity of the surface presented by Pebble Beds to the succeeding formations, as well as their rather abrupt disappearance, may be accounted for by the peculiarities of the deposit and of the position of the area under consideration.

The local occurrence of the Keuper Basement Beds at Nottingham is, I believe, attributable to the same causes, and not to their having suffered partial removal by denudation. As I remarked in my paper, they have approximately the same distribution as the Bunter, and it was not until the commencement of the Waterstone period, that the old limits of the Bunter deposits began to be exceeded. For this reason and others which I stated, I consider that the base of this formation, conformable as it is to the underlying rocks, constitutes a most important horizon in the Trias. A. STRAHAN.

WREXHAM, *Nov.* 8*th*, 1881.

DR. CALLAWAY AND THE WEXFORD LOWER PALÆOZOIC ROCKS.

SIR,—This writer in his paper on these Wexford rocks (GEOL. MAG. November, 1881) adopts the principle of the Archæan geologists, which I must again protest against, which is rushing to conclusions without a proper previous examination. In Donegal we are now told that undoubtedly there are Laurentian rocks, while in reality the question there has not been worked out since Jukes first suggested they were Laurentian rocks; and now Dr. Callaway states my work is all wrong, without first seeing it. As stated by him, anxious to arrive at the truth I pointed out all places where anything was to be seen, and specially the sections that were most important, and of the latter I specially called his attention to the Crossfarnoge section, and those on the Saltee Island. To get to the latter there may be a little trouble; but in my course through life I have always found nothing important can be done without some trouble. Under present circumstances I could not answer Dr. Callaway; he does not know my work; and until he does, it would be unfair to expect he could understand it. Furthermore, before he could understand Wexford, where so few rocks are exposed, he would have to examine an area where they are better seen. There could be no better field than Hiar-connaught, where, on account of the absence of Drift, the rocks in places can be studied as if laid down on a map.

I am at a loss to understand where Dr. Callaway learned that I have changed my opinion as to the age of the rocks north of the Carboniferous trough south of Wexford town. Those rocks were called Cambrians by Jukes, and a short time after I first saw them, I found *Oldhamia* in them. That I am aware of, I published no "views" on the rocks until after the examination of years, and the views first published are those I believe in still. In the *Times* report of the Brit. Assoc. Meeting, York, an Archæan geologist called me a geological Ishmael. I think, however, if he had called me a Knox or a Luther or a Calvin, this name would have been more appropriate; my hand not being against every one; but only against those that promulgate errors.

Ovoca, *Nov. 4th*, 1881. G. H. Kinahan.

RATE OF DENUDATION OF LAND BY RIVERS.

Sir, — Mr. Tylor's astounding calculation, that during the "Pluvial" period "the mean denudation" of the land was *nine inches per annum, or* 729 *times its present rate*, has filled me and probably other geologists with profound astonishment. Having just perused Mr. Darwin's most excellent book on Mould and Earthworms, it has occurred to me to ask Mr. Tylor to suggest what became of earthworms during his "Pluvial" period. Mr. Darwin calculates that ten tons of earth per annum per acre is frequently brought to the surface in the form of worm casts, and that the superficial soil has passed *again and again through the bodies of the worms.* Nine inches of soil over an acre of land would weigh, at a carter's estimate of one cubic yard to the ton, not less than 1210 tons.

No mould could possibly form under these circumstances, except perhaps in deltas, as it would be removed 100 times as fast as made. But I am really understating Mr. Tylor's estimate, as his nine inches of denudation means solid rock, or nearly double, or say 2000 tons per acre per annum. T. Mellard Reade.

Park Corner, Blundellsands,
Nov. 9th, 1881.

LAURENTIAN (?) ROCKS, IRELAND.

Sir,—In the epitome of the paper read on these rocks at the Brit. Assoc. York, by Prof. Hull, you end it by stating that I suggest there are Laurentian rocks in the Co. Tyrone. I cannot understand why I am to be made an advocate in favour of the present Laurentian mania. More especially as in my paper read before the Royal Irish Academy, and in a recent paper in the Geol. Mag., I believe I have brought forward good reasons for supposing these Tyrone rocks to be of Cambrian age. G. Henry Kinahan.

Ovoca, *Nov.* 5. 1881.

MISCELLANEOUS.

The Geological Survey.—In the Geological Magazine for January, 1881, we drew attention to some recent Parliamentary statements concerning the Geological Survey. Since then Mr. Mundella has announced that the solid Geological Survey of England and Wales on the one-inch scale will be completed in two years and a half, while a considerable portion of the solid and superficial Survey of Ireland will be completed in seven, and that of Scotland in eleven years. He was informed that the re-survey for superficial geology of those areas of England which were originally surveyed for solid geology alone, would take about twenty years. It was hoped that within the next few months the re-organization of the staff for remaining surveys would be completed, and no efforts would be spared to finish the work at as early a date as possible.—*Standard*, Aug. 19.

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