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NEW SERIES. DECADE III. VOL. VII.

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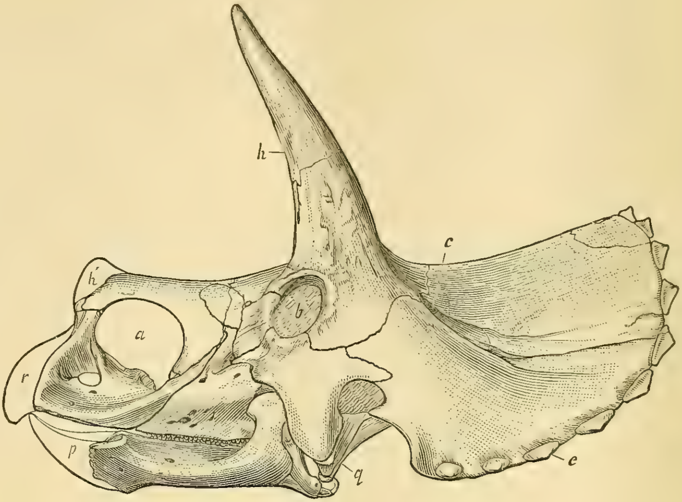
LIST OF WOODCUTS.

LIST OF PLATES.

1.



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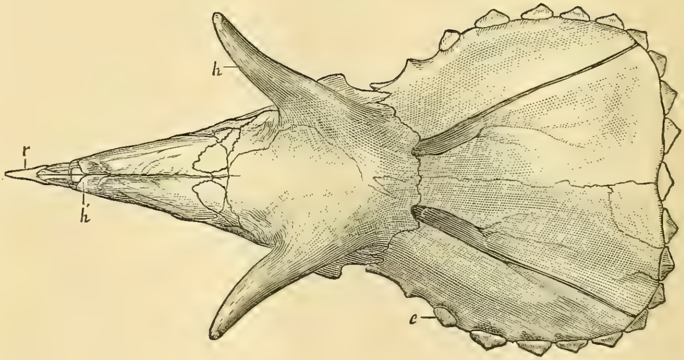


TRICERATOPS FLABELLATUS, Marsh. $\frac{1}{20}$ natural size.

Fig. 1.—The skull; seen from the side.

Fig. 2.—The same; seen from above.

a, nasal opening; *b*, orbit; *c*, supra-temporal fossa; *e*, epoccipital bone; *h*, frontal horn-core; *h'*, nasal horn-core; *p*, pre-dentary bone; *q*, quadrate; *r*, rostral bone.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VII.

No. I.—JANUARY, 1890.

ORIGINAL ARTICLES.

I.—The Skull of the Gigantic Ceratopsidæ.[1]

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

(PLATE I.)

THE huge horned Dinosaurs, from the Cretaceous, recently described by the writer,[2] have now been investigated with some care, and much additional light has been thrown upon their structure and affinities. A large amount of new material has been secured, including several skulls, nearly complete, as well as various portions of the skeleton.

The geological deposits, also, in which their remains are found, have been carefully explored during the past season, and the known localities of importance examined by the writer, to ascertain what other fossils occur in them, and what were the special conditions which preserved so many relics of this unique fauna.

The geological horizon of these strange reptiles is a distinct one in the Upper Cretaceous, and has now been traced nearly eight hundred miles along the eastern flank of the Rocky Mountains. It is marked almost everywhere by remains of these reptiles, and hence the strata containing them may be called the Ceratops beds. They are freshwater or brackish deposits, which form a part of the so-called Laramie, but are below the uppermost beds referred to that group. In some places, at least, they rest upon marine beds which contain invertebrate fossils characteristic of the Fox Hills deposits.

The fossils associated with the *Ceratopsidæ* are mainly Dinosaurs, representing two or three orders, and several families. Plesiosaurs, Crocodiles and Turtles of Cretaceous types, and many smaller reptiles, have left their remains in the same deposits. Numerous small mammals, also of ancient types, a few birds, and many fishes, are likewise entombed in this formation. Invertebrate fossils and plants are not uncommon in the same horizon.

The *Ceratopsidæ*, as the most important of this assemblage, will be first described fully by the writer, under the auspices of the United States Geological Survey. In the present paper, the skull of one of these gigantic reptiles is briefly described, and figured, as a typical example of the group.

[1] Abstract of a paper read before the National Academy of Sciences, Philadelphia, November 14, 1889.

[2] American Journal of Science, vol. xxxvi. p. 477, December, 1888; vol. xxxvii. p. 334, April, 1889; and vol. xxxviii. p. 173, August, 1889.

The Skull.

The skull of *Triceratops*, the best known genus of the family, has many remarkable features. First of all its size, in the largest individuals, exceeds that of any land-animal, living or extinct, hitherto discovered, and is only surpassed by that of some of the Cetaceans. The skull represented in Plate I., the type of the species, is that of a comparatively young animal, but is about six feet in length. The type of *Triceratops horridus* was fully adult, and probably an old individual. The skull, when complete, must have been over eight feet in length. Two other skulls, both nearly perfect, now under examination by the writer, fully equal in bulk the two already described, and other similar specimens from the same horizon maintain equal average dimensions.

Another striking feature in the skull of this genus is its armature. This consisted of a sharp cutting beak in front, a strong horn on the nose, a pair of very large pointed horns on the top of the head, and a row of sharp projections around the margin of the posterior crest. All these had a horny covering of great strength and power. For offence or defence, they formed together an armour for the head as complete as any known. This armature dominated the skull, and in a great measure determined its form and structure.

The skull itself is wedge-shaped in form, especially when seen from above. The facial portion is very narrow, and much prolonged in front, as shown in Plate I. Fig. 2. In the frontal region, the skull is massive, and greatly strengthened to support the large and lofty horn-cores, which formed the central feature of the armature. The huge, expanded parietal crest, which overshadowed the back of the skull and neck, was evidently of secondary growth, a practical necessity for the attachment of the powerful ligaments and muscles that supported the head.

The front part of the skull shows a very high degree of specialization, and the lower jaws have been modified in connection with it. In front of the premaxillaries, there is a large massive bone, not before seen in any vertebrate, which has been called by the writer, the rostral bone (*os rostrale*). It covers the anterior margins of the premaxillaries, and its sharp inferior edge is continuous with their lower border. This bone is much compressed, and its surface very rugose, showing that it was covered with a strong horny beak. It is a dermal ossification, and corresponds to the pre-dentary bone below. The latter, in this genus, is also sharp and rugose, and likewise was protected by a strong horny covering. The two together closely resemble the beak of some of the turtles, and as a whole must have formed a most powerful weapon of offence.

In the skull figured on Plate I. the rostral bone was free, and was not secured. This was also true of the predentary bone, and the nasal horn-core. Hence these parts are represented in outline, taken from another specimen, in which they are present, and in good preservation.

The premaxillary bones are large, and much compressed transversely. Their inner surfaces are flat, and meet each other closely on the median line. In old specimens, they are firmly coössified with each other, and with the rostral bone. They send upward a strong process to support the massive nasals. Another process, long and slender, extends upward and backward, forming a suture with the maxillary behind, and uniting in front with a descending branch of the nasal. The premaxillaries are much excavated externally for the narial aperture, and form its lower margin. They are entirely edentulous.

The maxillaries are thick, massive bones of moderate size, and subtriangular in outline when seen from the side. Their front margin is bounded mainly by the premaxillaries. They meet the pre-frontal and lachrymal above, and also the jugal. The alveolar border is narrow, and the teeth small, with only a single row in use at the same time. The teeth resemble, in general form, those of *Hadrosaurus.*

The nasal bones are large and massive, and greatly thickened anteriorly to support the nasal horn-core. In the skull figured on Plate I. these bones are separate, but in older individuals, they are firmly coössified with each other, and with the frontals. The nasal horn-core ossifies from a separate centre, but in adult animals it unites closely with the nasals, all traces of the connection being lost. It varies much in form in different species.

The frontals form the central region of the skull, and have been greatly strengthened to support the enormous horn-cores which tower above them. These elevations rest mainly on the frontal bones, but the supra-orbitals, the post-orbitals, and the post-frontals, have, apparently, all been absorbed by the frontals, to form the solid foundation for the horn-cores.

These horn-cores are hollow at the base, and in form, position, and external texture, agree closely with the corresponding parts of the *Bovidæ.* They vary much in shape and size in different species. They were evidently covered with massive pointed horns, forming most powerful and effective weapons.

The orbit is at the base of the horn-core, and is surrounded, especially above, by a very thick margin. It is oval in outline, and of moderate size. Its position and form are shown in Plate I. Figure 1 *b.*

The enormous posterior crest is formed mainly by the parietals, which meet the frontals immediately behind the horn-cores. The margin is protected by a series of special ossifications, which, in life, had a thick horny covering. These peculiar ossicles, which extend around the whole of the crest, may be called the epoccipital bones (Plate I. Figures 1 and 2, *e*). In old animals, they are firmly coössified with the bones on which they rest.

The lateral portions of the crest are formed by the squamosals, which meet the parietals in an open suture. Anteriorly, they join the frontal elements which form the base of the horn-core, and laterally, they unite with the jugal. The supra-temporal fossæ lie between the squamosals and the parietals, as shown on Plate I. Figure 2, *c.*

The base of the skull has been modified in conformity with its upper surface. The basi-occipital is especially massive, and strong at every point. The occipital condyle is very large, and its articular face, nearly spherical, indicating great freedom of motion. The basi-occipital processes are short and stout. The basi-pterygoid processes are longer, and less robust. The foramen magnum is very small, about one-half the diameter of the occipital condyle. The brain-cavity is especially diminutive, smaller in proportion to the skull, than in any other known reptile.

The exoccipitals are also robust, and firmly coössified with the basi-occipital. The supra-occipital is inclined forward, and its external surface is excavated into deep cavities. It is firmly coössified with the parietals above, and with the exoccipitals on the sides. The post-temporal fossæ are quite small.

The quadrate is robust, and its head much compressed. The latter is held firmly in a deep groove of the squamosal. The anterior wing of the quadrate is large and thin, and closely united with the broad blade of the pterygoid.

The quadrato-jugal is a solid, compressed bone, uniting the quadrate with the large descending process of the jugal. In the genus *Triceratops* the quadrato-jugal does not unite with the squamosal. In *Ceratops*, which includes some of the smaller, less specialized, forms of the family, the squamosal is firmly united to the quadrato-jugal by suture. Above this point it shows a number of elevations, which are wanting in *Triceratops*.

The quadrato-jugal arch in this group is strong, and curves upward, the jugal uniting with the maxillary, not at its posterior extremity, but at its upper surface, as shown in Plate I. Fig. 1 This greatly strengthens the centre of the skull which supports the horn-cores, and also tends to modify materially the elements of the palate below. The pterygoids, in addition to their strong union with the quadrate, send outward a branch which curves around the end of the maxillary. This virtually takes the place of the transverse bone. The latter is thus aborted, and is represented only by a small free ossicle resting upon the posterior extremity of the maxillary.

The lower jaw shows no specialization of great importance, with the exception of the pre-dentary bone already described. There is, however, a very massive coronoid process rising from the posterior part of the dentary, which is well shown in Plate I. Fig. 1. The articular, angular, and surangular bones, are all short and strong, and the splenial is comparatively slender. The angle of the lower jaw projects but little behind the quadrate.

The unique characters of the skull of the *Ceratopsidæ* are especially the following:—

(1) The presence of a rostral bone, and the modification of the pre-dentary to form a sharp, cutting beak.

(2) The frontal horn-cores, which form the central feature of the armature.

(3) The huge expanded parietal crest.

(4) The epoccipital bones.
(5) The aborted transverse bone.

These are all features not before seen in the *Dinosauria*, and show that the family is a very distinct one.

The peculiar armature of the skull has a parallel in the genus *Phrynosoma*, among the Lizards, and *Meiolania*, among the Turtles, and it is of special interest to find it also represented in the Dinosaurs, just before their extinction.

Such a high specialization of the skull, resulting in its enormous development, profoundly affected the rest of the skeleton. Precisely as the heavy armature dominated the skull, so the huge head gradually overbalanced the body, and must have led to its destruction. As the head increased in size to bear its armour, the neck first of all, then the fore limbs, and later the whole skeleton, was specially modified to support it.

These features will be discussed in a later communication, but to the present description of the skull should be added the fact that the anterior cervical vertebræ were firmly coössified with each other, an important character not before observed in Dinosaurs.

The skull represented on the accompanying Plate is the type specimen of *Triceratops flabellatus*, Marsh. It was found in the Ceratops beds of Wyoming by Mr. J. B. Hatcher, who also discovered the type of the genus *Ceratops*, in the same horizon in Montana.

II.—Did the Great Rivers of Siberia Flow Southwards and not Northwards in the Mammoth Age?[1]

By H. H. Howorth, Esq., M.P., etc.

THE question proposed in the heading to this paper seems a startling one. That the drainage of such a wide continental area as Northern Asia should have been entirely reversed at such a recent geological period as the Mammoth age, so that its present great drains, the Ob, the Yenissei and the Lena, did not exist at all, but their places were taken by other rivers pouring their waters, not into the Arctic basin, but into some great Mediterranean Sea in Central Asia, seems a paradox. It is nevertheless a conclusion which has been forcing itself upon me for a considerable time, and which I should like to be allowed to argue.

To begin with the current movement of the land in Northern Siberia, there can be no doubt whatever that the whole northern seaboard of the continent is rising rapidly from the water. Erman, Middendorff, and Wrangel, all diligent and careful explorers, are as one in regard to their lesson, which is that the northern part of Siberia, and, may I add, of Siberia in Europe also, that is to say, of the whole continent from the White Sea to Berings Straits, is rising from the sea. In a paper I wrote many years ago, which was published in the Journal of the Geographical Society, on Recent

[1] Full text of paper read in Section C (Geology) at the British Association, Newcastle-upon-Tyne, September, 1889.

Changes in Circumpolar Lands, I collected evidence of this fact, which is now an elementary postulate in physical geography.

That this rise has gone on for a long time is undoubted. It is equally undoubted that it has not gone on always, since we can measure the ultimate limit of the movement by the shells and other debris of the former tide-marks; the lines of shells, etc., found furthest south being a measure of the former extension southward of the Arctic Sea. What is plain is, that that sea has been shrinking, and is now shrinking very rapidly, and a great deal of what was under water and under ice not long ago is now dry land. This is universally admitted.

What is not so generally conceded, what in fact seems to have been entirely overlooked, is, that the result towards which this upheaval of the land and this shrinking of the Arctic Sea are tending was, in fact, reached during the Mammoth age, when it seems to be very certain, as I have tried to show in the Geological Magazine, 1889, p. 305, that a large part of the Polar basin was occupied by land and not by water, that the level of the northern part of the great Siberian plain was very considerably higher, and that the period of submergence from which Northern Siberia is now escaping is a new feature, which followed upon a period of higher-level of the dry land in the Arctic region in the Mammoth age.

If the sea-bottom of the Arctic Ocean was sufficiently elevated to be laid bare over a large portion of the area east of Nova Zembla, there can be small doubt that the Western Siberian rivers could not flow in their present beds. The fall of these rivers is proverbially very slight, and it would be a good deal slighter if they had not carved furrows in which to flow, out of the tundras which they thread. So slight is their flow that in places they seem in a doubtful attitude as to whether they should run north or south. A few figures will be the best evidence of this. These figures I owe to my friend Mr. Ravenstein, who tells me they are absolutely and not merely barometrically correct, having been the result of a spirit-levelling operation carried out between 1875 and 1878. They refer to towns situated for the most part near the head-waters of the rivers in question or their feeders. Tobolsk 266 feet, Omsk 279 feet, Tomsk 302 feet, Krasnoyarsk 499 feet. The rivers Ob and Yenissei, however, have high banks, and have cut down their beds very deeply, so that we may take it that the real drop of these rivers from their upper reaches is certainly not more but probably considerably less than 250 to 300 feet.

Now the deepest known soundings in the eastern part of the Arctic Sea show a depth of about 25 fathoms, and inasmuch as recent Arctic shells have been found by Seebohm 500 feet above the present sea-level, this shows that since the Mammoth age the oscillation of level has been over 100 fathoms. An elevation of from 40 to 50 fathoms, however, operating along the Arctic borderland of Asia, would suffice to entirely reverse the drainage of the great rivers, which must in such a case have flowed southwards. This is a very curious induction, and seems inevitably to follow from any postulate demanding a land-bridge between Siberia and America in the Mammoth age.

If the conclusion be sound, we ought to be able to apply an easy test to it, and to find abundant traces of the fact (if not, in the river-beds themselves, where the evidence might easily be obliterated), in the Central Asiatic area, for assuredly such a reversal of the flow of these enormous water-ways must have created an immense Mediterranean Sea in Central Asia.

Evidences of this sea are not only forthcoming, but they are so palpable and plain that it has become an axiom of physical geography that such a sea existed at no distant date. The proofs of it are various and converging. In the first place, the scattered lakes which dot this part of Asia from the Caspian to Lake Balkhash, whose common fauna can only be explained on the hypothesis that they are the fragments of a once continuous sheet of water, "Relikten seen" as the Germans call them, and secondly the great stretches of arid sand containing semi-fossil shells of species still living in the lakes referred to, and marked by saline deposits, sands known to the natives as the Karakum or black sands, Kizilkum or red sands, etc.[1]

Here then we get a double argument in favour of the contention I am arguing for. The *a priori* argument deducible from the effects of the rise of the Arctic sea-bed and the *a posteriori* argument deducible from the actual state of things in Central Asia, the latter being an argument universally conceded and hitherto needing only a rational explanation. While every one allows that a great sea once occupied the Aralo-Caspian depression, it has hitherto been a desideratum to know how this sea could have been supplied with its water, and how it resisted the desiccating effects of the Siberian climate, which are now so obvious. If, as we contend, the great rivers Obi and Yenissei at this date poured their waters into the Asiatic Mediterranean, the whole problem is explained.

I would add as a curious corollary, that the great plain of European Russia, which is in many ways a mere prolongation of Asia, and which was in the Mammoth age still more closely united with it in its physical characteristics, still retains its ancient slope, and its great rivers, the Volga, the Don, the Dnieper, and the Dniester still flow southwards. In the Mammoth age their waters were probably further recruited by that which goes to form the Petchora and the Neva. Apart from this last divergence, it seems rational to conclude that Eastern Europe at this moment presents a very close type of what Western Siberia once presented, and that the whole continent from the Caspian to the valley of the Yenissei then had a southern slope and was bounded on the south by a continuous sheet of water, of which the Black Sea and Lake Balkhash are the terminal relics.

I have limited my induction in regard to Asia to Western Siberia, but I have small doubt that what was true of the Obi and the Yenissei was true of the Lena also; but here the change that has since occurred in the contour of the country is greater and more complicated, and I will defer its discussion to another occasion.

[1] See S. P. Woodward, Manual of the Mollusca, p. 291, on the range of *Cardium rusticum*, *ibid.* Proc. Zool. Soc. July 8, 1856, part II.

The effects of this change of physical feature must obviously have been manifold. The existence of a great Central Asiatic Sea would greatly temper the Siberian climate, while the southern flow of its rivers would affect the distribution of animal and vegetable life, and offers at least a reasonable solution of the difficulties surrounding the migration of birds in the Palæarctic region, while it finally sweeps away the hypothesis that the Mammoth remains of Siberia are the wreckage of river portage.

III.—Note on the Classification of the Red Rocks in South-East Durham; and on a possible unconformity between the Trias and the Permian Limestone in the same District.

By H. H. Howell, F.G.S., etc.,

Director of the Geological Survey of Scotland.

THE several bore-holes which have been put down through the Red Rocks in the south-east part of the county Durham to win the bed of Rock Salt there have directed attention to the age and classification of these rocks.

Mr. Edward Wilson in an exhaustive paper published in the Quarterly Journal of the Geological Society of London, has strongly supported the classification adopted and expressed on the maps of the Government Geological Survey of that district.

Mr. Howse, in the "Guide to the Collections of Local Fossils in the Museum of the Natural History Society, Newcastle-on-Tyne," recently issued, classes the whole of the Red Rocks down to and including the Salt-bed as Trias, but does not divide them into Upper and Lower divisions. He says, "It seems better to conclude that the red shales and sandstones at the mouth of the Tees represent a peculiar and local development of the Trias than attempt to split it up into divisions that have no exact representatives either in England or on the Continent."

Professor Lebour, formerly on the staff of the Geological Survey in Northumberland, in the "Handbook to the Geology and Natural History of Northumberland and Durham," which appears to be in part a re-issue (in the form of an "Official and Local Guide" prepared by him for the meeting of the British Association at Newcastle in 1889), of the second edition of his "Outlines of the Geology of Northumberland and Durham," published in 1886, gives his most recent views on the classification of the rocks between the Permian Magnesian Limestone and the Drift. He gives the following scheme merely as representing his own opinions derived from a careful examination of the evidence at present available on the subject:—

	Avicula contorta Beds ... ... (Proved in Eston shaft and boring.)	Rhætic.
7.	Red and Green Marls with Gypsum (known only south of the Tees)	Upper Trias.
6.	Red Sandstone	
	Unconformity ??	
5.	Red Sandstones and Marls	Lower Trias.

	Unconformity ? ?	
4.	Red Marly Sandstones, Marls, with lenticular beds of Anhydrite, Gypsum, and Salt, and fœtid limestone in variable bands towards the base	UPPER PERMIAN (Rauchwacke).
3.	Thick Magnesian Limestone	MIDDLE PERMIAN.
2.	Marl Slate	
1.	Yellow Sands	LOWER PERMIAN.
	Unconformity.	

And further on, at p. 31, Professor Lebour criticizes the scheme adopted by the Geological Survey. I give the extract in full. He says, "When I first entered upon the study of this question, I was strongly prejudiced in favour of the view of the stratigraphical relations of these beds which is represented by the scheme according to which the maps of the Geological Survey are coloured, viz. :—

	RHÆTIC.
UPPER TRIAS (Keuper).	Red and Green Marl with Gypsum, 6 feet. Red and White Sandstone with bed of Red Marl, Gypsum and Rock Salt, 5 feet.
PERMIAN.—Magnesian Limestone.	

But there seems to be no good reason, in the total absence of fossils, for separating what I have called No. 4, into two divisions, the lower with and the upper without limestones. It is true that the reason for separating No. 5 from No. 4 is scarcely stronger, except that there is a distinct evidence that the former division now occupies a larger area than the latter, which is proof of overlap, if not of unconformity. There is also some, though less, evidence of No. 6 overlapping No. 5, or being unconformable to it, and there seems to be *absolutely nothing in favour of the assumption* that (whichever classification be adopted) the Triassic Series is in South Durham only represented by the Keuper."

As I was District Surveyor in charge of the Geological Survey of that district, and to some extent responsible for the classification adopted and expressed in the maps of the Geological Survey, I may be permitted to explain the reasons which induced me to recommend that the whole of the red rocks lying between the Rhætics and the Durham Permian Limestone should be classed as Trias, and as belonging to the Upper or Keuper division of that formation.

Now the position of the Rhætic beds on the Yorkshire side of the Tees is well known, and beneath them there is something like from 400 to 500 feet of Red Marls—the Keuper Marls—which graduate down into Sandstones with beds of Red Marl—the Lower Keuper Sandstones or Waterstones—of other districts in Britain. Down to this horizon I believe all are agreed—there is no difference of opinion—that these strata belong to the Keuper division of the Trias.

But in this district beneath these undoubted Keuper beds, there is a great—an abnormal thickness of sandstones, sandy marls, and marly sandstones, with thick deposits of gypsum and anhydrite at their base, with which the bed of Rock Salt is associated, which cannot be very well correlated with other districts.

When I was engaged on the Geological Survey there, the difficulty presented itself to me as to what these red rocks should be called, and it was not neglected. Any one who will look at the Drift editions of the Geological Survey maps will see at a glance that the whole of the low-lying district bordering on the Tees in S.E. Durham and North Yorkshire is covered by an almost unbroken sheet of Glacial Drift and alluvial deposits which mask the underlying solid rocks; therefore sections of the red rocks exposed at the surface are few and far between. They are visible at Seaton Carew, and up the Tees at Coatham Stob, Dinsdale, Hurworth, and Croft. I examined all these sections, and it was my opinion then and it is my opinion now that the rocks have a distinctly Keuper aspect. They are not in the least like the Bunter—the soft upper and lower brick red sandstones with intervening pebble beds, which I mapped in my younger days in the Midland Counties, and which I was taught to regard as Bunter. I have also examined the cores of these rocks brought up at several bore-holes, and they tend to confirm me in this opinion. Neither could I find any trace of a physical break or unconformity within these red rocks—they seemed to be due to one continuous deposition. In the face of this evidence it does seem to me that it would have been absurd to split up the red rocks into divisions and draw hypothetical lines separating Keuper Sandstones and Marls from Bunter Sandstones and Marls, and Bunter Sandstones and Marls from Permian marly Sandstones and Marls. Therefore, I felt compelled to carry the base-line down to an horizon where the lithological characters were marked and distinct, viz. to the junction of the red rocks with the Durham Permian Limestone. And there is also at this horizon, I think, some evidence of a possible unconformity. I use the word "possible" advisedly, because I am not very sure that the position of the Triassic rock on the Permian Limestone may not be explained in another way. But the evidence for the unconformity, such as it is, is this. At the Seaton Carew bore-hole, I think it has been undoubtedly proved that the red rocks with gypsum and anhydrite at their base rest upon the upper division of the Durham Permian Limestone—that division which comes to the surface in the cliffs at Hartlepool and at other places along the Durham coast. The stratigraphical position of this division is from 700 to 800 feet above the Marl Slate. Then again in the flat country bordering upon the estuary of the Tees numerous bore-holes have been put down through the red rocks to work the salt-bed there, and some of these borings have been carried down into limestones beneath the salt-bed. It has been stated more than once that these limestones were not fossiliferous, and could not be identified with any beds coming to the surface at the outcrop. As regards one bore-hole this is most certainly a mistake. I refer to the one which was put down for the Newcastle Chemical Company on reclaimed land on the north side of the Tees opposite Middlesborough. I was consulted about this boring from the first, therefore I am well acquainted with it. The section of the red rocks passed through agreed very closely with that of neighbouring bore-holes, with the exception of the absence of the salt-bed, which was unfortunate commercially, but does not materially affect the question under discussion.

I recollect very well when resident at Darlington, Mr. Wilton Allhusen bringing me a portion of the first core of limestone which had been bored through, and asking my opinion whether the horizon of the salt-bed had been passed, and whether there was any prospect of success by continuing the bore-hole deeper into the limestone.

I told him the fact of reaching the limestone after passing through the red rocks without finding the salt-bed proved the latter to be absent, and that there would be no prospect of success by going deeper into the limestone. But Mr. Alfred Allhusen was more sanguine, and the boring was continued to a greater depth. The result was that no salt-bed was found, but some very interesting cores of limestone were brought up.

I examined these cores, and on one occasion I was accompanied by Mr. Howse, Curator of the Museum of Natural History, Newcastle-on-Tyne, and Dr. Veitch, of Middlesborough. Mr. Howse saw that the limestone was fossiliferous, and his well-trained eye at once detected the small *Axinus* (*Axinus dubius*), and it was also noted that a roestone bed similar to one which occurs in the limestone forming the cliffs at Hartlepool had been passed through. Here then I think there is undoubted proof that the red rocks rest upon the uppermost division of the Durham Permian, as at Seaton Carew.

I now wish to direct attention to the western outcrop of the red rocks in the neighbourhood of Darlington, Leeming Lane (where the Vale of Mowbray Brewery is situate), and Ripon. There we have sandstone and marls underlaid by thick deposits of gypsum (as much as 40 feet was proved at the well at the Vale of Mowbray Brewery), which in turn rest directly upon the Permian Limestone. Here, however, they rest, not upon the upper division—the Hartlepool beds—but upon the fossiliferous and compact limestone zone of the Durham Permian—that division which immediately overlies the Marl Slate. It is on these grounds that I think there is some evidence of an unconformity, and that the red rocks may be transgressive over the various divisions of the Durham Permian Limestone from Hartlepool to Darlington and Leeming Lane.

I may add a word upon the lowest set of beds—limestones, and marls with gypsum and rock salt (14 ft.)—proved in the trial bore-hole of Messrs. Bell Brothers at Saltholme beneath the main bed of rock-salt.

The late Director-General of the Geological Survey, Professor (now Sir Andrew) Ramsay, in his Presidential Address to the British Association at the meeting at Swansea in 1880, refers to this lowest set of beds, and claims the 14 feet bed of rock-salt proved beneath the limestone to be of Permian age. He says, "In the North of England, at and near Middlesborough, two deep bore-holes were made some years ago in the hope of reaching the Coal-measures of the Durham Coal-field. One of them at Saltholme was sunk to a depth of 1355 feet. First they passed through

74 feet of superficial clay and gravel, next through about 1175 feet of Red Sandstones and Marls with beds of rock-salt and gypsum. The whole of these strata (excepting the clay and gravel) evidently belong to the Keuper Marls and Sandstones of the upper part of our New Red series. Beneath these they passed through 67 feet of dolomitic limestone, which in this neighbourhood forms the upper part of the Permian series, and beneath the limestone the strata consist of 27 feet of gypsum and rock-salt and marls, one of the beds of rock-salt having a thickness of 14 feet. This bed of Permian Salt is of some importance, since I have been convinced for long that the British Permian strata were deposited, not in the sea, but in salt lakes comparable in some respects to the Great Salt Lake of Utah, and in its restricted fauna to the far greater salt lake of the Caspian Sea."

I do not think the late Director-General ever saw the cores of the strata passed through in the Saltholme boring, but I examined them, and I think he must have formed his opinion from the recorded section and my description of them, and also from analyses of two samples of the limestones, one taken from the bed at the depth of 1261 feet, and the other at a depth of 1320 feet. These analyses were kindly given to me by Mr. T. Hugh Bell for the use of the Geological Survey, and I showed them to the late Director-General who visited me in his official capacity when I was resident in Darlington.

Mr. Edward Wilson is not inclined to admit the Permian age of these "limestones" and the salt-bed which has been proved beneath them. He demurs to the use of the term "limestone" as applied to the whole of these beds, and designates them instead "indurated marls." He adds, "Although there appear to be dolomitic or calcareous, as well as dark bituminous beds among them, they show no sort of resemblance to any known beds of the Magnesian Limestone of Durham; on the other hand, they possess the characteristic greenish colour of certain Keuper Marls, as well as a similar texture, and probably also mineral composition, although decidedly harder than most of the rock of that series." On these grounds Mr. Wilson classes these strata with the Keuper division of the Trias.

I append the analyses, of what I believe to be fair samples of the strata bored through at the depths above mentioned, and they seem to me to be something more than "indurated marls."

Sample of Magnesian Limestone from the bore-hole (Saltholme), 1261 feet:—

Carbonate of lime ...	54·71
,, ,, magnesia	41·18
,, ,, iron ...	·81
Silica	2·00
Alumina	trace
Water	1·08
Bitumen	·22
	100·00

Limestone from the bore-hole, underlying the Magnesian Limestone, sample 1320 ft. depth:—

Carbonate of lime	94·48
,, ,, magnesia	2·98
,, ,, iron	·78
Silica	1·20
Alumina	0·20
Bituminous matter	·36
	100·00

Mr. Howse in a paper entitled a "Note on the South Durham Salt Borings, with remarks on the Fossils found in the Magnesian-Limestone Cores, and the Geological Position of the Salt,"[1] of which he has kindly sent me a copy, discusses the age of the limestones and underlying salt-bed and marls at the Saltholme boring. He strongly supports the view that they are of Permian age. He examined the cores soon after the boring was completed, and "came to the conclusion that this limestone and marl were identical with the Upper Limestone and Red Marl of Sedgwick, the Brotherton Beds, and Red Marl of Kirkby, as exposed at Knottingly, Brotherton, and other places in the south of Yorkshire; and that it was also identical with the 'Plattendolomit' of Geinitz, as seen near Gera, in the outskirts of the Thuringerwald, and many other parts of Germany."

IV.—Coal in the South East of England.

By W. Whitaker, B.A., F.R.S., F.G.S.

"WITH regard to the probability of coal under cretaceous rocks in the South of England it seems hardly possible to conceive that the commercial enterprise of Englishmen could have failed to discover it long ago if it had been in existence."

The above quotation, from a Presidential Address, by Mr. H. Hall,[2] might serve as the text for a short discourse on the commercially unenterprising character of one's fellow-countrymen, who have done practically nothing in the matter!

A deep trial-boring was certainly made some years ago, near Battle: but the Sub-Wealden Boring was not a matter of commercial enterprise. Other deep borings have also been made in the South of England, which partake more of the character of work referred to, though only as regards the getting of water, not the least idea of looking for coal having influenced those who made them. It is indeed to the enterprise of corporations, of companies, and of Government, in the search for water, that we owe almost all our direct knowledge of the rocks underlying the Cretaceous beds of the London Basin.

Just one trial-boring is being made in search for coal, strange to say by a Railway Company; but, though extraordinary rumours

[1] Natural History Transactions of Northumberland, Durham, and Newcastle-on-Tyne, vol. x. part ii.

[2] Trans. Manchester Geol. Soc. vol. xx. p. 388, and earlier in various weekly newspapers.

now and then come from Dover, practically nothing is known, beyond the very small circle of the highly privileged few, of what has been found there. Since the above was written however a welcome announcement has appeared that Prof. Boyd Dawkins hopes before long to let anxious geologists know something about the matter. May he have something fresh to tell us![1]

As a geologist I must decline to be in any way bound by the lamentable failure, or one may say the heartrending absence, of commercial enterprise amongst my fellow-Englishmen. I have elsewhere given a lengthy account of what has been published on the subject of the old underground rocks of the London Basin, and, in summing up the general conclusions that, to my mind, may fairly be drawn, as to the possible occurrence of Coal Measures, have ventured to say, "it seems to me that *the day will come when coal will be worked in the South East of England.*"[2]

I am glad to say, however, that there is now an opening for the development of enterprise in the scientific investigation of the deep-seated geology of south-eastern England. Mr. J. T. Day, F.G.S., impressed with the importance of the question, "Is there Coal under the London Basin?" has issued a circular, from which the following extracts are taken:—

"This question has frequently been asked, but no systematic attempt has ever been made to answer it."

"If it should be found that coal does exist at workable depths, and within easy reach of the metropolis, the value of the discovery . . . would be enormous."

"With the view, therefore, to a systematic investigation of the matter, it is proposed to raise a fund of 2000 guineas to meet the cost [of trial-boring]. This fund will be presided over . . . by a committee to be selected from amongst the subscribers."

"Promises of support . . . should be sent to . . . J. T. D," [12, Albert Square, Stepney, London, E.].

Cash is not asked for, only promises, to be redeemed when a settled plan has been arrived at. Presumably before starting any work a strong committee of experts would be consulted, and it should be mentioned that both Prof. Prestwich and Prof. Judd are in favour of the scheme.

All those who take an interest in the question should communicate with Mr. Day, who wishes it to be understood that his proposal is not put forward on commercial grounds, although it appeals to commercial instincts as well as to the wish for further knowledge in a very important matter.

Such being the state of the case, I am anxiously awaiting the appearance of "commercial enterprise," coupled with scientific inquiry.

[1] Trans. Manchester Geol. Soc. vol. xx. p. 352.

[2] The Geology of London, etc., vol. i. p. 46 (1889). Reviewed in Geol. Mag. Dec. 1889, p. 568.

V.—Notes on the Devonian Fishes of Scaumenac Bay and Campbelltown in Canada.[1]

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

THE researches of the officers of the Geological Survey of Canada have brought to light, in the Devonian rocks of Scaumenac Bay and of Campbelltown, a series of fossil fishes which are of especial interest to the geologist as well as to the zoologist, on account of the analogies which they bear to the fishes of the Old Red Sandstone of Great Britain. Principally collected by Mr. G. H. Foord, these fishes have been described by Mr. J. F. Whiteaves,[2] and are indeed remarkable for their beautiful state of preservation, which enables them to throw fresh light on many points in the structure of these ancient forms. From a purely geological standpoint their interest is not less, as we shall see.

The Edinburgh Museum having been fortunate enough to obtain a valuable collection of these fishes, I am enabled to supplement Mr. Whiteaves's descriptions, as well as to add at least two additional species to the list.

I. *Fishes from the Upper Devonian of Scaumenac Bay.*

Ctenodontidæ.

Phaneropleuron curtum, Whiteaves.—As Mr. Whiteaves points out, this species is distinguished emphatically from the Scotch *Ph. Andersoni* by its comparatively short and deep outline, which in this case is certainly not due to distortion. Some of the Edinburgh specimens show the Ctenodont dentition very clearly, but in no case have I seen the "smooth, conical and somewhat compressed teeth," which Mr. Whiteaves mentions as arming both the upper and under jaw. And here I must make an important correction. In his second quarto memoir (1889) Mr. Whiteaves refers to a fragment collected by Mr. Foord in 1881, in which the eye is situated very far forwards and surrounded by a complete circle of about 26 circumorbital plates. Referring also to the suborbitals and preoperculum, which are also shown in the specimen, he says that they are "exactly similar to the corresponding plates in *Eusthenopteron*." Now, if we refer to the figure given of this specimen (ib. pl. x. fig. 1), it will be seen that this exact similarity is shared also by the anterior half of the cranial buckler which is present, as well as by the maxilla, and the jugular plate. Moreover, the orbit does not occupy that position in *Phaneropleuron curtum;* for according to a specimen now before me, it is placed, as in *Ph. Andersoni*,[3] comparatively far back, and not much in front of the

[1] Read before Section C of the British Association at Newcastle-on-Tyne, September 16th, 1889.

[2] Am. Journ. Sc. and Arts (3), xx. 1880; Canad. Naturalist, n. ser. x.; Am. Naturalist, xix. 1885; Canad. Nat. and Quart. Journ. Sc. n.s. vol. x. 1881. Mr. Whiteaves's detailed descriptions are given in two quarto memoirs entitled "Illustrations of the Fossil Fishes of Canada," from the Trans. Roy. Soc. Canada, vol. iv. sec. iv. 1886, and vol. vi. sec. iv. 1888.

[3] On the position of the orbit in *Phaneropleuron Andersoni* see Traquair, Geol. Mag. Vol. VIII. 1871, pp. 530–531.

operculum. In fact, there can be no doubt that the specimen referred to by Mr. Whiteaves belongs to *Eusthenopteron Foordii,* and not to *Phaneropleuron* at all. The "circumorbital" plates are, as we shall see under *Eusthenopteron,* sclerotic in their nature.

Pterichthyidæ.

Bothriolepis Canadensis, Whiteaves.—Remarks on this species will be found in my paper on the "Structure and Classification of the Asterolepidæ," Ann. and Mag. Nat. Hist. for Dec. 1888.

Cephalaspidæ.

Cephalaspis laticeps, sp. nov.—Only one specimen, which shows the cranial shield, with badly-preserved traces of the body. Shield proportionately rather broad, length $1\frac{5}{8}$ inch, breadth $2\frac{3}{4}$ inches, cornua short: orbits rather close together, oval, large: tesselated divisions of middle layer very small: external surface ornamented by small, smooth, polished and rounded tubercles, moderately close in position.

This is the first occurrence of a Cephalaspid in rocks of later age than the Lower Devonian, and as such is worthy of the attention of the geologist.

Acanthodidæ.

Acanthodes concinnus, Whiteaves.—This is a true *Acanthodes,* and differs remarkably in the sculpture of the scales from all the other species of the genus.

Mesacanthus affinis, Whiteaves, sp.—At first Mr. Whiteaves was inclined, though doubtfully, to refer this little fish to *Acanthodes Mitchelli* of Egerton, from the Forfarshire beds; subsequently, however, he decided to retain it as distinct, though still apparently with doubt, as he speaks only of there being "some reason for supposing that this interesting little fish is distinct from the *A. Mitchelli* of the Devonian rocks of Scotland." It is, however, only necessary to place specimens of the two forms side by side to see that they are quite distinct, as the scales of the Canadian species are proportionally very much larger than in *Mitchelli.*

Owing to the very distinct presence of a pair of small spines intermediate between the pectorals and ventrals in *A. Mitchelli,* and in *A. Peachii,* Eg., I have proposed to include them in the new genus *Mesacanthus,*[1] including also, from its general aspect, *A. pusillus,* Ag., from the Moray Firth beds, although our specimens of the latter are not well enough preserved to show them. Here I would also place *M. affinis,* as in one specimen I at least imagine I see one of those minute intermediate spines.

Holoptychiidæ.

Glyptolepis Quebecensis, Whiteaves.—The collection in the Edinburgh Museum contains one head of a small Holoptychian fish which I provisionally refer to this species, although unfortunately no body is present: equally unfortunately, the head in the only specimen described by Mr. Whiteaves is not well enough preserved to show

[1] Geol. Mag. Dec. III. Vol. V. 1888, p. 511.

its structure or markings. This head displays the typical Holoptychian osteology and dentition, the laniaries of the under jaw being acutely conical, and striated to near the apex: they seem, however, to be round in transverse section.

Mr. Whiteaves at first referred his *Glyptolepis* to *G. microlepidotus* of Agassiz, though with some doubt, and even in his subsequent detailed description, in which he adopts the name *Quebecensis*, he still seems to be uncertain as to its distinctness or the contrary. For he says: "As it seems impossible to decide from the description and figure of *G. microlepidotus* in Agassiz's monograph whether the Canadian species is identical with it or not, it seems safer to give the latter a provisional name until the true specific relations of each shall have been ascertained by a direct comparison of specimens from both sides of the Atlantic."

There is, however, no need for regarding the name *Quebecensis* as provisional, so far as any possible identity with *microlepidotus* is concerned. For Mr. Whiteaves's figure shows a true *Holoptychian*, and *probably* a *Glyptolepis*, whereas Agassiz's *G. microlepidotus* is not referable to *Glyptolepis* at all, nor even to the same family. That fish is, as I have shown (Geol. Mag. Dec. III. Vol. V. 1888, p. 514), a true Rhizodont, and is, I believe, both generically and specifically identical with McCoy's *Gyroptychius angustus*.

Rhizodontidæ.

Eusthenopteron Foordii, Whiteaves.—The characters which Mr. Whiteaves gives as distinguishing his genus *Eusthenopteron* from *Tristichopterus*, Egerton, are briefly as follows:—

1. That "the vertebral centra of *Eusthenopteron* do not seem to to have been ossified at all," whereas "in *Tristichopterus* on the other hand the vertebral centres are stated to be completely ossified."

2. That the large bones bearing the three ossicles which directly support the second dorsal and the anal fin in *Eusthenopteron* are interspinous in character, whereas "the corresponding bones in *Tristichopterus* are represented as spinous rather than interspinous in their character, and as each abutting directly on the vertebral axis."

3. The much greater vertical symmetry of the caudal fin in *Eusthenopteron*.

4. The presence of two cutting edges in the laniary teeth of *Eusthenopteron*.

Reasons 3 and 4 certainly hold good whether they be of generic value or not. But such is not the case with the first and second. For specimens of *Eusthenopteron Foordii* now before me show undoubtedly the presence of vertebral centra in the anterior part of the body at least, these being in the form of hollow rings as in *Rhizodopsis*, and I am firmly of opinion that the vertebræ of *Tristichopterus* are in the same condition, and that "in this genus the ossification and segmentation of the vertebral column" was *not* "complete," as supposed by Sir Philip Egerton. And also as regards the large fin-supporting bones alluded to in the second reason, I am equally of opinion that Sir Philip Egerton was in error in considering them to be spinous, and not interspinous. It would indeed be odd if so great a morphological difference existed between such similar elements in such closely-allied fishes. Comparing specimens of *Eusthenopteron* and *Tristichopterus* in the Edinburgh collection, there can be no doubt as to their *exceeding* similarity of structure, though the differences mentioned in reasons 3 and 4 seem to me to justify the retention of the former generic name. It must be remembered, however, that in such questions much depends on the idiosyncracy of the individual writer—differences, which to some minds may seem generic, are not always of the same importance in the eyes of others.

Mr. Whiteaves describes the cranial buckler as divided by a transverse suture into two unequal parts, an anterior or *frontal*, and a posterior or *parietal* plate. This is of course true, but he makes no mention of the constituent bones of these two great divisions of the cranial shield, which can, in fact, only be made out when the shield is viewed from the internal or non-sculptured aspect. The posterior part may be seen in this way to consist of two elongated parietals, each of which is flanked by two smaller plates, a squamosal behind and a postfrontal in front, exactly as in *Rhizodopsis*, *Osteolepis*, etc. Likewise the anterior portion consists of two frontals in contact with each other in the middle line, but without the pineal foramen seen in many Osteolepids (*Osteolepis*, *Diplopterus*, *Thursius*), while in front of these, and received posteriorly in an angle between their anterior extremities is an oblong median ethmoidal, flanked on each side by a lateral ethmoidal, while the space between these and the premaxillæ is apparently covered by a number of small polygonal plates as in Holoptychids, Rhizodonts, and Osteolepids generally. I have remarked above that the sutures between these plates can only be seen when the cranial shield is examined from the internal aspect; on the outside nothing is seen but a median groove, noticed by Whiteaves, separating the two frontals, and bifurcating in front behind the median ethmoid.

A circle of small quadrangular or slightly wedge-shaped plates occurs in the position of the eye, of which six are seen in one specimen before me, while in Mr. Whiteaves's paper five are represented in his restored figure (pl. vi. of his second quarto paper), and the whole circle, "about twenty-six," in the specimen erroneously referred to *Phaneropleuron* (*ib.* pl. x. fig. 1). Of these plates Mr. Whiteaves observes that they "are probably homologous with the circumorbitals of Traquair's restoration of *Dapedius*, as well as suggestive in a general way of the still more highly specialized sclerotic plates in the eye of *Ichthyosaurus* and *Megalosaurus*."

Now, as it is clear that these little plates cannot be both of two such very different things at once, a choice must be made, and from their shape and their position relative to the other bones in the head in which I have observed them, I have no doubt that they are sclerotic and not circumorbital in their nature. If this view be correct, we have in *Eusthenopteron* a condition almost unique among fishes, for though sclerotic ossifications are not uncommon amongst them, in no fish except certain Cœlacanths do they assume the form of a continuous ring of quadrangular plates as they do in recent Birds and Lizards and in extinct Ichthyosauria and Stegocephala.

The plate labelled "preoperculum" by Whiteaves consists in reality of three pieces, as in *Rhizodopsis*, *Megalichthys*, etc., of which only one, the narrow semilunar posterior division (see my figure of the head of *Rhizodopsis*),[1] can be supposed to represent a preoperculum, the other two being cheek-plates. Here I must confess to have also failed to observe this in my previous study of *Tristichopterus*,[2] as a re-examination of the same specimens incontestably proves the presence of the same elements in that genus.

The mandible shows very distinct evidence of being composed of the same elements as in *Rhizodopsis* and *Rhizodus*. The laniary teeth are like those of *Rhizodus* in miniature, being rounded and fluted at the base, smooth and two-edged higher up. A transverse section of the fluted portion shows that the dentine is here thrown into complex labyrinthine foldings. I can see none but small teeth on the maxilla, as in other Rhizodonts and Osteolepids, but the vomers are, as usual, armed with strong tusks. Mr. Whiteaves states that "in *Eusthenopteron*, as in *Tristichopterus*, no trace can be detected of an azygos jugular plate, or of any small lateral plates." There is certainly no median jugular, but in one of our specimens the presence of five narrow lateral jugulars is very distinctly shown. No specimen of *Tristichopterus* as yet known is well enough preserved in this region to show these small lateral plates.

A very great interest attaches to the internal skeleton of the paired fins, which in the case of the pectoral is tolerably accurately figured by Mr. Whiteaves, though he does not seem very decided as to the interpretation to be placed upon the arrangement shown. There is a segmented axis consisting of four bony segments or mesomeres, placed end to end, each being slightly constricted in the middle. Each of these, except the last, has likewise attached to it on the preaxial side of its distal extremity, a small bone, also constricted in the middle and passing outwards and backwards at an acute angle; these small bones being clearly parameres. The first mesomere, and in one case also the third, gives off likewise on its postaxial side a flat backwardly directed process, which is certainly only a process and not a distinct bone. I may here also state that there is some evidence of an additional mesomere in advance of or proximally situated to that which I have termed the first, and bearing no paramere. A very similar arrangement is found in the pelvic fin, whose internal skeleton was not perfectly preserved in Mr. Whiteaves's specimens; here I find at least two mesomeres, each bearing a paramere, there being, I think, also a probability of the presence of a third or distal mesomere.

The arrangement seen in the pectoral fin of *Tristichopterus*, which I figured in 1874,[3] is essentially the same as that described above, though at the time I wrote my description of the last-mentioned genus, and taking the condition of preservation of the specimen into

[1] Trans. Roy. Soc. Edin. vol. xxx. 1881.
[2] Trans. Roy. Soc. Edin. vol. xxvii. 1874.
[3] Trans. Roy. Soc. Edin. pl. xxxii. fig. 9.

account, I did not feel quite certain as to whether I should consider the postaxial processes of certain mesomeres as parameres or not. The internal skeleton of the pectoral in the Carboniferous *Rhizodopsis*, as I have observed it in specimens belonging to Mr. Ward, F.G.S., of Longton, is also constructed on the very same plan.

It follows, then, that the skeleton of the paired fins in the Rhizodontidæ is an abbreviate uniserial "archipterygium," and if, as seems probable, the Holoptychiidæ are the more archaic group, then the Ceratodus-like pectoral of *Holoptychius* is a more primitive form of limb. This paired-fin skeleton in *Eusthenopteron* and its allies may therefore, along with the corresponding conditions in *Pleuracanthus* and *Cladodus*, be considered of special interest in connection with the "archipterygium question."

PALÆONISCIDÆ.

Cheirolepis Canadensis, Whiteaves.—Unfortunately the Edinburgh Museum contains only a few fragments of this species, so that I have no means of comparing it thoroughly with the Scottish specimens of the genus, all of which, in my opinion, are referable to *one* species only, *Ch. Traill*, Ag.

II. *Fishes from the Lower Devonian of Campbelltown.*

COCCOSTEIDÆ.

Phlyctænius, nov. gen. *Ph. Acadicus*, Whiteaves, sp.—On examining several pretty good specimens of this curious Coccostean, named by Mr. Whiteaves *Coccosteus Acadicus*, I find that it exhibits certain characters which are neither in accordance with those of the genus *Coccosteus*, nor with Mr. Whiteaves's diagram of its cranial shield. Allied to *Coccosteus* it is, as the arrangement of the sensory grooves, correctly indicated in Mr. Whiteaves's figure, clearly shows. But the sutures between the bones are only seen with the greatest difficulty; indeed Mr. Whiteaves admits that the dotted lines in his figure only represent their "supposed outlines." Accordingly he has indicated by means of those dotted lines certain plates having the same general outline as the median-occipital, lateral-occipital, and central plates in *Coccosteus decipiens*, Ag., whereas the real outline of these plates seems to me to be very different. The median-occipital, instead of being trapezoidal, with long posterior margin, shorter anterior one, and convergent sides, appears elongated and five-sided, there being an anterior acute angle which is received in a notch between the two centrals in front, which are themselves also elongated and more or less of a six-sided contour. Laterally the external occipital, marginal, and postorbital may be easily made out, and I think the preorbitals are also apparent enough. The orbital portion of the shield (= the part between the letters *d* and *e* in Whiteaves' figure) are rather more anterior and look more forwards than in *Coccosteus*. None of our specimens show Mr. Whiteaves's "rostral" plate, which is evidently the equivalent of that which I have called anterior ethmoidal in *Coccosteus decipiens*.[1]

[1] *Homosteus* compared with *Coccosteus*, GEOL. MAG. Dec. III. Vol. VI. Jan. 1889, Pl. I. Fig. 2 *a*, *e*.

The difference in the form of those bones of the cranial shield seems to me certainly to be of generic importance, and I doubt not but that many other important differences would be apparent were the remains more complete. (I may remark that the plate figured by Mr. Whiteaves as a "ventro-median (?) plate" cannot be so, as it is not bilaterally symmetrical.) I therefore propose for it the generic name *Phlyctœnius.*

It is also of considerable interest to note that the Edinburgh Museum also possesses a small Coccostean head from Cradley, Herefordshire, which is referable to the same genus as the above. A description of this, the first known Coccostean from the West of England, is reserved for the next Number of the Geological Magazine.

Cephalaspidæ.

Cephalaspis Campbelltownensis, Whiteaves.—Mr. Whiteaves mentions as a character of this species that the surface displays little pits instead of the characteristic tuberculation. The outer surface does not seem to me to be preserved in the Campbelltown Cephalaspidæ any more than it is in those from some localities in Forfarshire.

In its contour the shield of *C. Campbelltownensis* is, however, proportionally considerably broader than in *C. Lyelli*, though this may partly be due to these shields in the Campbelltown deposits being always crushed out quite flat. The orbits are proportionally further back from the front of the shield.

Cephalaspis Whiteavesi, sp. nov., Traq.—Buckler triangular in general appearance, rather acutely and conspicuously pointed in front, cornua rather prolonged and incurved, orbits large, polygonal tessellation somewhat coarse. Surface ornament not seen.

This is a most striking form, no hitherto described species of *Cephalaspis* having that remarkably pointed anterior contour which indeed reminds us of the front of a Skate. I beg therefore to dedicate the species to Mr. Whiteaves, who has been the first to describe the fishes from Scaumenac and Campbelltown.

Acanthodidæ.

Mr. Smith Woodward has already pointed out that the species named by Whiteaves *Ctenacanthus latispinosus* and *Homacanthus gracilis* are Acanthodian in their nature, and are not distinguishable from those of *Climatius.*[1]

Gyracanthus.

A veritable Selachian ichthyodorulite has, however, turned up in the shape of a new species of *Gyracanthus*, to which I apply the name *G. incurvus*. The length of the spine is $2\frac{1}{8}$ inches, but though the point is entire, some of the base has been lost, so that originally it must have been a little longer. It shows an antero-posterior curvature of a very much stronger and more pronounced description than is found in the young forms of any hitherto described species, and this together with the great delicacy of its ornamentation distinguishes it as new. The ornamentation consists of rather fine

[1] Ann. and Mag. Nat. Hist. (6) iv. p. 183.

ridges passing with a very slight obliquity over the side of the spine; this obliquity increases towards the base as well as towards the anterior aspect, where the ridges are also rather coarser than posteriorly. The ridges are plain at the apex, but soon become crenulated, the crenulations being more pronounced on the anterior aspect.

That this species belongs to the genus *Gyracanthus* is fully shown, not merely by the nature of the ornament, but by the obliquity of the posterior area, the prominent edge of which is armed with a row of minute denticles.

Gyracanthus has hitherto not been known to exist below the horizon of the Carboniferous rocks. Its occurrence in the Lower Devonian of Canada is therefore as interesting a fact as the occurrence of *Cephalaspis* in the Upper Devonian of the same country.

VI.—Notes on the Geology of the Gironde, with Especial Reference to the Miocene Beds.

By George F. Harris, F.G.S.

DURING the past summer I had the pleasure of studying the Miocene and Upper Oligocene beds at various places in the Bordelais, mostly under the guidance of the amiable Professor of Geology in the Faculté des Sciences in Bordeaux, Monsieur E. Fallot; and the following notes are mainly intended to give an idea of the present appearance of the classical Miocene sections in that district, and to say something concerning their classification and that of the other Tertiary beds of the Gironde, following the most recent researches on the subject. In doing so, the names of the principal localities rich in fossils will be prominently brought forward (supplemented by a table at the end of the article), chiefly with a view to enable us readily to fix the exact horizons of specimens in museums and private collections in this country.

The Tertiary beds overlie the Upper Cretaceous, and these, the only Secondary beds cropping out in the Department of the Gironde, are found near Villagrains and Landiras. They mostly consist of yellowish compact limestone with flints and the few fossils that have been collected, especially the Echinoderms, indicate that both the Sénonien and Danien divisions are present.

Eocene.

The Lower Eocene nowhere rests on the yellow chalk at its outcrop, but in well-borings, beds probably of this age are met with. M. Benoist believes[1] that a limestone with *Crenaster* and *Orbitoides* in a well at the Chateau of Vigneau is about the age of the Calcaire de Mons of southern Belgium, which latter it might be mentioned is intermediate in age between our Thanet beds and the uppermost Chalk. Above the *Crenaster* limestone, a conglomerate surmounted by clays and lignites appears, and these the same authority regards as the equivalents of the lignites of the Soissonais of the Paris

[1] Journ. d'Hist. Nat. de Bordeaux, 1887.

basin, which are on about the same level as our Woolwich and Reading series. Following on above these in a well-boring in Blaye, sands and sandstones occur containing *Nummulites planulata*, var. (aplatie), believed by M. Benoist to be the equivalents of the Sables de Cuise of the Paris basin, on about the same horizon as the uppermost part of the London Clay and the Lower Bagshot beds (London sands) of the London basin.

It is noteworthy that if M. Benoist's classification is correct, the general succession of the Lower Eocenes of the Gironde is not very different to that of the south of Belgium and northern portions of the Paris basin, except that the equivalents of the Thanet sand are missing in the Bordeaux district. Even the lignitic character of the analogues of the Woolwich and Reading series is persistent.

M. Fallot, however, is of opinion that M. Benoist is rather too sanguine about the evidence obtainable from the well-borings. He regards[1] most of the conclusions as to correlative age as hypothetical, although he admits that just outside the Department, near Saint-Palais (Charente-Inférieure), the equivalents of the Sables de Cuise are found. He raises a question as to whether the *Nummulites* are correctly determined.

There is no doubt whatever that Middle Eocene beds are found in the Gironde. The lower portions termed "Couches à *Nummulites*," mostly sands and sandstones, are found only in well-borings. The lowermost Eocene bed cropping out at the surface is the Calcaire Grossier, and both the upper and the lower divisions of this formation occur with characteristic fossils such as *Strombus ornatus*, *Potamides angulosus*, *P. tricarinatus*, and *Delphinula conica*, at Blaye. The Calcaire Grossier is approximately equivalent to our Bracklesham beds.

Above these come the "Bartonien" series of clays, marls and lacustrine limestones, characterized by the usual *Ostrea cucullaris*, *Limnea longiscata*, *Planorbis rotundatus*, etc. The lower portion of the series corresponds to the "Sables de Beauchamp" (part of the Sables Moyens) of the Paris basin, or in part to our Barton beds; and the upper to the "Calcaire de Saint-Ouen" or our Upper Bagshot sands. The Bartonien beds in the district under discussion are found principally in the Blayais and the Médoc.

The Upper Eocene (French classification) or "Ligurien" crops out at various places in the northern half of the Department, more especially in the Blayais, the Médoc, and near Saint-Vivien. This subdivision of the Tertiaries in the Gironde is known also as the "Calcaire marin de St.-Estèphe." It is specially characterized by *Sismondia occitana*, which occurs in great abundance. M. Benoist has recognized[2] three horizons:—

1. Upper zone with *Clavagella Moulinsi*.
2. Middle zone with Echinoderms.
3. Lower zone with *Miliolites* and *Orbitolites*.

[1] Esquisse Géol. du Dept. de la Gironde (Feuille des Jeunes Naturalistes, xix. an.), 1889, p. 5.

[2] "Desc. des communes de St.-Estèphe et de Vertheuil," p. 12.

The upper zone contains numerous molluscs which serve to fix the correlative age of the deposit. Amongst them may be cited *Rostellaria* (*Rimella*) *fissurella*, *Calyptræa trochiformis*, *Turritella sulcifera* and *Diastoma costellata*. These have a distinctly Calcaire Grossier appearance, but M. Fallot says[1] that the bed being above the *Limnea longiscata* limestone places it rather on the horizon of the Upper than the Middle Eocene of the Paris basin. I cannot help thinking, however, that correlation by means of fresh-water limestones containing long-range species is a rather doubtful proceeding. These local fresh-water beds are liable to occur at various horizons in the Eocene and Oligocene.

At Grave, Bonzac, and other places, clay with *Palæotherium* is classed with the Upper Eocene, but the higher portions of the beds are believed to be the equivalents of the horizon to be next described.

Certain marls and loose sandstones above the *Sismondia* limestone which crop out in the same districts as that bed, are of doubtful age. They are divided into two parts, the upper being characterized by *Anomia girondica*, and the lower by *Ostrea bersonensis*. The upper series at the quarry of Meynieu near Vertheuil contains a fauna having considerable affinities with the Tongrien (Oligocene). They seem to be passage-beds between the Eocene and Oligocene.

Oligocene.

The beds classed under this division of the Tertiaries were, all of them, called Lower Miocene by old authors, and much confusion has thus arisen, though the alteration was in some respects a very good one. I would particularly call attention to the fact that in consequence of this change in nomenclature a great many of the excellently-preserved fossils in our Museums labelled "Dax[2] (Gaas) Miocene," "Bordeaux Miocene," etc., are not in reality Miocene fossils, but Oligocene. Where the precise locality is attached to the specimens, it ought not to be difficult to assign them to their proper age, and even where this information is not given, the colour of the matrix of the bed, together with the correct identification of the species, enables any one familiar with the beds in the field to say definitely, in regard to the majority of the specimens, whether they are Oligocene or Miocene. Further, the particular formation of either division to which they belong could also by this means in most cases be indicated. The recognition of these facts opens up the question whether, in describing species supposed to be new to science, English palæontologists have given that close attention to the so-called Miocene species (really Oligocene) of the Aquitaine basin that they might have done. We are all aware of the tendency of many authors to "create" new species almost solely on the ground that they occur in different, rather widely separated, subdivisions from other species having the closest affinity to them, and which, if they only occurred in one and the same deposit, would be regarded as specifically identical or varietal at most. For instance, suppose

[1] *Op. cit.* p. 8.

[2] Dax is in the Department of the Landes, but seeing that many authors allude to the locality in connexion with Bordeaux Miocenes, I thought it desirable to mention the place.

English Upper Eocene mollusca are being identified, I fancy very few would give more than the most superficial glance at works on fossils called (under the old nomenclature) Miocene, and yet on the transference of portions of these latter to the Lower Oligocene, we are presented with a fauna of the same age as our Headon beds. I was very much struck with the close resemblance of several species of the Oligocene mollusca in the Bordelais with those of the Oligocene beds of the Isle of Wight, and I believe many of them are specifically identical, whilst others certainly ought not to rank higher than "varieties," though the mollusca referred to are now regarded as entirely distinct species. On the present occasion, however, I do not propose to go further into this matter.

The Oligocene beds of the Gironde are divided into two étages, the Tongrien and the Aquitanien.

The *Tongrien* is subdivided into four parts:

1. Lower mollasse of Agenais.
2. *Asterias* limestone.
3. Lacustrine limestone of Castillon.
4. Mollasse of the Fronsadais.

No. 4 is, generally, a greenish sandy clay without fossils. At Fronsac certain beds under this have been called "infra-mollassiques" by MM. Fallot et Croizier.[1] It is difficult to give the precise age of these and of several other beds found on about the same horizon in certain parts of the Department; but according to the views of the former observer, they constitute a passage between the Eocene and Oligocene.

No. 3 is not very persistent in character. In the typical locality it is a white limestone with flints, containing fresh-water mollusca, which seem to indicate that it is approximately of the age of the "Calcaire de Brie" of the Paris basin.

No. 2 is also known as the Bourg or Saint-Macaire limestone, and is the most typically developed Tongrien bed in the district. The lower part, well developed near Libourne, contains *Ostrea cyathula* and *O. longirostris*. The upper or true *Asterias* limestone forms the hills between Roque-de-Tau and Bourg, the high ground bordering the Dordogne, and, generally, the south-eastern and central portion of the Department, and in certain places from Pauillac to Vendais, between the western bank of the Garonne and the sea. Characteristic fossils are *Trochus labarum*, *Natica* (*Ampullina*) *crassatina*, *Pectunculus angusticostatus*, *Delphinula scobina* and *Lucina Delbosi*. The general facies, M. Fallot says,[2] is that of the "Sables de Fontainebleau" of the Paris basin.

No. 1 is a green or yellow clay with calcareous concretions; in some localities the beds are more or less sandy, but interesting on account of the occurrence in them of *Anthracotherium*, *Rhinoceros*, and other mammals.

The higher subdivision of the Oligocene—the Aquitanien—is generally split up into three assises:—

1. Upper.—Grey limestone of Agenais.
2. Middle.—Bazas sandstone, and middle mollasse of Agenais.
3. Lower.—White limestone of Agenais.

The Aquitanien beds crop out principally in the south-east of the

[1] Actes Soc. Lin. de Bordeaux, tome xl. p. 55.
[2] "Esquisse Géol. du Dept. de la Gironde," 1889, p. 10.

Gironde, but also in many river-valleys to the south and west of Bordeaux. The upper and lower Aquitanien have generally a fresh-water facies, whilst the middle is marine; but this does not hold good in the western portions of the area under consideration. As they are traced westwards, the fresh-water beds gradually become more marine in character, and, as might naturally be supposed, it is next to impossible to define the three assises where this is the case; the latter have, therefore, only a local value in the Agenais.

The Aquitanien beds presenting the greatest interest, perhaps, to English palæontologists are those found in the valleys round Saucats and La Brede, about twelve miles south of Bordeaux, for the majority of the Bordelais Oligocene fossils come from thence. The district has been most admirably described by M. Tournouër,[1] and the following useful zones have been established, the oldest, as usual, being placed at the bottom:—

5. Marly lacustrine limestone, with *Helix girondica*, *Limnea girondica* and *Dreissina Brardi.*
4. An argillaceous bed with *Potamides* in one place and a marine bed in another.
3. Lacustrine limestone of Saucats.
2. A loosely compacted sandstone corresponding to the Bazas sandstone, and known to Bordeaux geologists as "roche sableuse jaune."
1. Blue and white clays with *Neritina Ferusaci* (*Nerita picta*).

These form the first (lowest) five zones of what are known as "les couches faluniennes" of that author.

The bed No. 4 at Lariey (about two miles north-east of Saucats) is very fossiliferous, containing many species originally called "Lower Miocene." Under M. Fallot's guidance, I succeeded in obtaining a large number from a few small openings, amongst which may be mentioned *Cyllenina baccata*, var. *minor*, *Proto Basteroti*, *Calyptræa sinensis*, *Chama Brocchi*, *Lucina dentata*, *Terebra* (*Hastula*) *cinerea*, and *Cytherea undata*.

The same horizon is met with under another guise in a road-section on the way to Son, between Lariey and Saucats, but nearer the former place. The locality is sometimes referred to as "Moulin de l'Eglise." In this road-cutting one sees zones 3, 4, and 5. Here zone 4 has changed into a brackish-water fauna chiefly composed of *Potamides.*

Miocene.

This comprises the Middle and Upper Miocene of old authors. Beds of this age occupy the greater portion of the western half of the Gironde; but they are so completely covered by superficial deposits, mostly by the "Sable des Landes," that they are visible at but very few points, situated almost exclusively in river-valleys which have been cut by ordinary river action, down through the "sable" alluded to. The beds are divided into four parts, forming, in upward succession to the Bordelais Aquitanien beds, a further instalment of "les couches faluniennes," and numbered as follows:—

9. Faluns of Salles and Sime, with the mollasse of Martignas.
8. Faluns of Saucats and Cestas.
7. Typical falun of Léognan, and those of Cassagne and Lagus.
6. Mollasse of Léognan, with the lower faluns of Léognan and those of Giraudeau and Peloua.

[1] "Bull. Soc. Géol. de France," 2e ser. tome xix. p. 1039.

These are grouped into étages. Nos. 6 to 8, both inclusive, belong to M. Mayer-Eymar's "Langhien" and No. 9 to the "Helvétien," and although this nomenclature is generally accepted by Bordeaux geologists, M. Fallot points out [1] that it is not strictly applicable to the Miocenes of the Gironde. Neither are the Austrian divisions (1st and 2nd Mediterranean étages). The uppermost division of the Miocenes, the Tortonien of Italian geologists, does not seem to occur in the department.

Langhien.—Above the Aquitanien beds at Léognan, some sandy deposits belonging to No. 6 contain many Echinoderms, having at the base a zone with fish-teeth, etc., notably *Notidanus*, *Lamna*, *Oxyrhina* and *Carcharodon megalodon.* In the valley of Saucats the mollasse of Léognan is represented at Giraudeau, near Moulin de l'Eglise, where the ferruginous-looking falun contains a very rich fauna. At the present time, however, this locality is rather disappointing, no section is to be seen, nothing but a planted field surrounded by woods meets the eye, yet the ground is literally covered with fossil mollusca, amongst which I brought away *Ancillaria glandiformis* (very characteristic of this assise), *Proto cathedralis*, *Voluta rarispina*, and *Pectunculus cor.*

About half-way between Giraudeau and the St.-Morillon railway-station one leaves the main road, and following a rough cart-track to the southward through the vines for about 200 yards, comes across the fossiliferous locality of Peloua. Here again there is no section, but it is one of the classical localities in the Bordeaux Miocenes, having yielded about 400 species of fossils. At the time of my visit, by good fortune, the most interesting part of the ploughed field was not planted with vines; if it had been, we should not have obtained permission to visit the spot, and this remark applies generally to many of the most interesting localities in the Bordelais. As it was, I picked up a large number of corals and mollusca. Amongst the latter were *Ranella tuberosa*, *Tudicla rusticula*, *Strombus Bonelli*, *Melongena cornuta*, *Potamides plicatus* and *Pecten burdigalensis.* The horizon of the Peloua zone is believed to be about the same as that at Giraudeau. M. Fallot pointed out to me the fact that the Peloua fauna contains almost all the species of *Potamides* found at Lariey and Moulin de l'Eglise (bed No. 4 of "les couches faluniennes"), to which places I have already referred, and it possesses other affinities linking it closely to the Oligocene, at the same time the general facies is decidedly Miocene. In the absence of sections, it is not easy to say what are the precise stratigraphical relations between the Miocene and Oligocene of the Bordelais, but the palæontological evidence certainly proves that the passage from the one to the other is very gradual.

Zone No. 7 at Léognan is divided into two parts, the lower being a yellow sand, the higher a blue clay, both of which contain numerous fossils. These beds are also represented in the valley of Saucats, the former at Cassagne, the latter at Moulin de Lagus. The last-mentioned place, very close to the village of Saucats, like

[1] "Esquisse," *op. cit.* p. 15.

TABLE OF

Classification of the Tertiary Beds of the Gironde (after Fallot).[1]						Assises faluniennes.	Approximate Homotaxial Relations in England.
PLIOCENE	Upper (Arnusien).		Lignite deposit of Soulac with *Elephas meridionalis*.				Forest-bed of Cromer (?).
	Middle and Lower.		Missing.				
MIOCENE	Tortonien.		Missing.				
	Helvetien		Faluns of Salles and Sime with *Cardita Jouanneti*. .... Mollasse of Martignas			No. 9	
	Langhien		Faluns of Saucats	Pont-Porquey Gieux, la Coquillière	Faluns of Cestas.....	No. 8	
			Typical falun of Léognan	Blue falun of the Wood of Léognan, Moulin de Lagus, etc. Yellow falun of Coquillat, the Cassagne, etc.		No. 7	
			Mollasse of Léognan and lower faluns of Léognan (Thibaudeau, Chât d'Olivier)	Red (ferruginous) Falun of Giraudeau Faluns of Peloua, Merignac supr., etc.		No. 6	
OLIGOCENE	Aquitanien	Upper	Grey lacustrine limestone of the Agenais.	Upper lacustrine limestone & upper fluvio-marine beds of the Bazadais.	Upper lacustrine limestone of the Son road-cutting (Moulin de l'Eglise)	No. 5	
					Falun of Lariey and of Son road-cutting, Merignac inf. etc.	No. 4	
					Lacustrine limestone of Saucats.	No. 3	
		Middle	Marine sandstone of Bazas, and middle mollasse of the Agenais.	Yellow sandy rock of Bordelais Valleys		No. 2	
		Lower	White lacustrine limestone of the Agenais.	Lower lacustrine limestone and lower fluvio-marine beds of the Bazadais.	*Neritina Ferrusaci* beds of the Bordelais.	No. 1	

	Tongrien		Lower Mollasse of the Agenais	Hempstead, Bembridge, Osborne, and Headon series.
		Asterias Limestone	*Asterias* limestone properly so-called	
			Ostrea longirostris, and *O. cyathula* marls	
			Lacustrine Limestone of Castillon and Civrac (Médoc)	
			Mollasse of the Fronsadais	
Beds of doubtful classification.			"Infra mollassiques" clays and fresh-water limestone of Fronsac	
			Beds with *Anomia*	
EOCENE.	Ligurien.		Limestone of Saint-Estèphe with *Sismondia*	Upper Bagshot series.
	Parisien.	Bartonien	Lacustrine limestone of Plassac. Marine beds of St Ysant and Bégadan	Barton series (in part).
			Ostrea cucullaris clays. *Corbula* marls of the Médoc	
		Lutétien	Calcaire grossier of Blaye: Upper limestone with *Echinolampas affinis*	Bracklesham series.
			Calcaire grossier of Blaye: Lower limestone with *Echinolampas stelliferus*	
			Nummulites beds of borings in the Bordelais	
	Suessonien		*Nummulites planulata* (?) beds of the Blaye borings	London Sands and part of London Clay series.
			Conglomerates and lignitic clays of the Vigneaux boring (?)	Woolwich & Reading series (?) Thanet sands (missing in the Gironde).
			Crenaster limestone of the Vigneaux boring (?)	(Calcaire grossier de Mons (?) (Belgium).)

[1] "Esquisse Géol. des Dept. de la Gironde" (1889) p. 23. I have altered M. Fallot's table in certain places, especially in regard to the Lower Eocene beds, this latter being after the views of M. Benoist ("Esquisse Géol. des terr. Tert. S-O de la France, Journ. d'Hist. Nat. de Bordeaux, 1887). See *ante* p. 23.

The table of English equivalents which I have ventured to draw up is necessarily imperfect; in the present state of our knowledge it is impossible to do more than indicate the approximate relationships of the different beds. For example, the uncertain position of the Saint Estèphe limestone and of the "infra mollassiques" clays renders it very difficult to parallel them exactly with English beds; whilst the synonymy and "undescribed species" of the mollusca in both areas cause exact comparisons of the fauna as at present known to be very misleading.

most of the "sections" in the district, is very difficult to find, unless under guidance. Leaving the village and following the course of the stream, which flows through the hamlet, we presently discover the Lagus section in the river banks, and in order to do any work it is necessary to wade in the deep water, and dig into the uneven ledges made by previous observers. The working is about 12 feet in vertical height, being entirely composed of a blue sandy clay. This is another of the classical sections of the district, having furnished many of the "type species" of the Bordeaux Miocenes. The floor of the broadest ledge, containing many deep pools of water, is literally covered over by *Turritella terebralis* in the finest state of preservation, and, altogether, about 200 species of fossils have been found here. Amongst those I brought away may be mentioned *Terebra Basteroti, Dorsanum veneris, Fusus burdigalensis, Tudicla rusticula, Xenophora* (= *Phorus*) *Deshayesi*, and *Proto cathedralis*. A Pteropod, *Vaginella depressa*, is also very common.

On the opposite side of the village the classical section in zone No. 8 is found. This cutting, known as Pont-Porquey, is by the side of the river, and composed of about ten feet (vertically) of light yellow sand. How much longer this section will be open I cannot say, the digging and searching for fossils along the best zone having caused the upper beds to be undermined, part overhanging so much as to be very dangerous to workers beneath. When this falls, almost the whole section will be obliterated. The best-preserved fossils of the Gironde Miocenes come from this opening, the species are mostly very small, but many still retain their original colour-markings, and, like several of the Vienna mollusca of approximately the same period, the best-preserved tints are orange-red and vermilion. The *Potamides* especially are most clearly colour-marked. Some common species are *Terebra* (*Acus*) *fuscata, Terebra plicaria, Cyllenina baccata, Potamides pictus, Donax transversa, Lucina columbella*, and *Oliva* (*Olivancillaria*) *Basteroti*.

Other localities on the same horizon (No. 8) are Gieux and La Coquillière, both near Saucats. Fresh-water beds are occasionally found in this falun.

At two or three other places in the Gironde, passage-beds between the Langhien and Helvétien occur.

Helvétien, No. 9.—In the commune of Martignas along the Jalle, a greyish yellow mollasse, remarkable for Echinoderms (such as *Echinolampas hemisphœricus*) crops out. This bed has been well described by M. Benoist,[1] but the best-known Helvétien bed in the Gironde is the falun of Salles on the banks of the Leyre, containing *Murex turonensis, Voluta Lamberti, Cardita Jouanneti, Corbula striata, Pectunculus pilosus*, etc. Other parts of this assise are seen at Sime and Cazenave. M. Fallot says that the falun of Salles contains many species found in the Tortonien of Baden (Austria).

It is very doubtful whether any Pliocene beds occur in the Gironde. Some geologists have thought that the "Sable des Landes" is, in part, of this age; but this view is not now generally held.

[1] "Actes Soc. Lin. de Bordeaux," t. xxxii. pp. 97, *et seq.*

The only exception, perhaps, to this is the lignitic deposit at Soulac, with *Elephas meridionalis,* which seems to be a remnant of the Upper Pliocene (Arnusien).

The "Sable des Landes" predominates everywhere between the Gironde and Garonne, and the sea. Its exact age, as we have seen, is not very clear, but it is older than the coast alluvium and dunes of the department.

The best centre, perhaps, to study the Bordelais Miocenes is the village of Saucats. Although it is only twelve miles from Bordeaux, this place is not very accessible, and to go to it and return to Bordeaux every day wastes much time. The village inn might afford worse accommodation. There is absolutely nothing to see in regard to sections in the immediate neighbourhood of Bordeaux itself, nearly all the classical Miocene sections being within a few miles of Saucats. Another good centre is Bazas.

In conclusion, I must express my hearty thanks to Professor Fallot for his kindness and assistance rendered during my visit to the Bordelais, and for giving me permission to study the fossils of the Tertiary basin of the south-west of France contained in the splendid private collection of the Faculté des Sciences under his charge.

VII.—Note on an Occurrence of Willemite in a Slag.

By W. Maynard Hutchings, Esq.

CRYSTALLIZED silicate of zinc, Willemite, has frequently been observed, artificially formed, in metallurgical operations, but so far as I am aware no case has been recorded of its crystallizing out from a magma of slag of a different composition, of which the zinc silicate formed only a comparatively small proportion.

Willemite has been observed in crusts of silicate formed in zinc-muffles during the working of zinc-ores. Stelzner and Schulze describe[1] crystals formed in this manner in cavities in the retorts in which they studied the formation of zinc-spinels. I have myself observed the mineral in very perfect rhombohedral crystals, occurring in cavities of firebrick supports of retorts, in such a manner that their formation was evidently due to zinc vapour passing through the material of the retorts and oxidizing in contact with the siliceous material of the firebrick. Ebelmen formed a crystallized zinc silicate by fusion of silica and zinc oxide in boric acid, but this product does not appear to have been proved to be crystallographically Willemite.

The occurrence I wish to record is in a slag produced in large quantity during the smelting of certain lead-dross containing zinc oxide in a small blast-furnace. The resulting slag contains 12—15 per cent. of zinc oxide, the remainder consisting almost wholly of a basic ferrous silicate.

In cavities in the large slag-balls, after solidification, large numbers of slender acicular hexagonal crystals were noticed. They

[1] Jahrbuch für Min. Geologie und Paläontologie, 1881, I.

were at first supposed to be apatite, like the crystals previously observed by me in a slag of somewhat similar nature.[1] Under the microscope, however, they proved to have very high double-refraction, of *positive* character. Chemical examination proved them to consist of silicate of zinc, with a little iron.

These crystals are as much as half an inch in length and of a thickness up to $\frac{1}{75}$ inch. The majority have no definite terminal faces, but many have perfect rhombohedral end-forms. They are pale yellow in colour, and distinctly dichroic, the ordinary ray being the more strongly absorbed. Nearly all the larger ones inclose a central core of dark amorphous matter.

Thin sections of the slag itself show that it consists mainly of olivine (Fayalite), principally in a confusedly crystalline form, but with a fair proportion of definite crystals. There is comparatively little residual amorphous base. Crystals of Willemite, of the same dimensions as those seen free in the cavities, lie in the olivine in all directions, and have been the first to form. The separation parallel to the basal plane is strongly developed, and cross-sections show, in addition to irregular cracks, a well-marked cleavage with intersections of 120°.

Both Fayalite and Willemite contain a large amount of crystals of magnetite. This latter contains a good deal of intercrystallized zinc-spinel, and is not very readily attacked by acid. It may be separated out by decomposing the slag with acid, evaporation, and solution of residual silica in caustic alkali. If the separated crystals are then digested for some time in strong hydrochloric acid, the magnetite proper is dissolved, leaving a residue of green zinc-spinels, mostly as hollow shells, and fragments of octahedra, but also showing some few perfect crystals.

The slag in which these Willemite crystals occurred was produced uninterruptedly during about 10 days' work of the furnace, and during the whole of this time the crystals could be seen in any ball of the slag which was examined. It may be interesting to note that during another run of the same furnace, producing a similar slag, with rather more than less zinc oxide, no Willemite was formed, either in cavities or in the massive slag. All conditions were the same, and the only difference in composition of the slag itself was that, whereas on the former occasion it contained about $1\frac{1}{2}$ per cent. of lead, the percentage of that metal had risen on the latter occasion to 5. Thin sections showed that there was here very much more amorphous, and nearly amorphous base, in which were large numbers of beautiful idiomorphic crystals of Fayalite.

Thus it would appear that a small amount of lead silicate, itself glassy, had the power to cause much of the slag to solidify in the glassy condition, and to prevent entirely the crystallization of the zinc silicate. Observations of this sort, made on slags, may throw a little light on the manner in which the structure and mineralogical composition of rocks may be greatly modified by apparently unimportant amounts of some one constituent.

[1] "Nature," Sept. 15th, 1887.

In this connection I may perhaps be allowed to refer again to the occurrence of apatite in slag, alluded to above. This still remains the only recorded case in which that mineral has been observed to crystallize from an artificial silicate magma, analogous to its occurrence in eruptive rocks. After first noticing it I had opportunity of seeing the slag in question formed almost continuously for many months. It would frequently happen that for days at a time no crystals of apatite could be seen in the cavities, and then again they would reappear in great quantity. Although much attention was given to the subject, nothing could be observed to account for either disappearance or reappearance, no change taking place in composition of the slag, or in conditions of formation and cooling.

Attempts were made by Dr. Cohen, of Owens College, to obtain apatite in small fusions in the laboratory. Pieces of the slag rich in apatite were melted in crucibles; similar fusions were made of mixtures of the constituents of the slag in the proportions shown by analysis, and both were subjected to a prolonged "récuit," as in the experiments of Fouqué and Lévy, but no apatite was ever formed.

The crystals of Fayalite formed in slags so very rich in iron show very strongly developed cleavages. Rosenbusch alludes to the fact that the cleavages are more distinct in olivine containing much iron, and this observation is fully borne out in thin sections such as those above alluded to.

NOTICES OF MEMOIRS.

I.—On the Manufacture of Serpentine in Nature's Workshop. By Major-General C. A. McMahon, F.G.S.[1]

THE rocks from which serpentine is mainly derived by an aqueous process are called peridotites though there are several varieties which receive distinctive names. They are all characterized by the predominance of the mineral peridote or olivine. Some meteorites exhibit a marked affinity with peridotites, containing, like the latter, olivine, rhombic and monoclinic pyroxene, and occasionally some basic felspar. Peridotites are not commonly found on the earth's surface, one reason being that olivine is an unstable mineral that readily absorbs water and passes into serpentine.

General McMahon detailed the various ways by which water finds its way into minerals; namely, by cracks; by planes of cleavage and of "chemical weakness"; and by capillary flow through the interspaces between molecules. In connection with the latter branch of the subject he gave a sketch of the kinetic theory as applied to solids, and of Boscovich's theory which helped to elucidate the kinetic hypothesis; and he stated that whether we accept these theories or not, we must give up the idea that the

[1] Abstract of a Discourse delivered before a Meeting of the Western Microscopic Club, London, on the 4th November, 1889.

molecules of which crystalline bodies are composed are compacted tightly together, like the cells of a honeycomb, without interspaces between them; and he referred to some experiments by Professor Heddle on the absorption of water by granites and greenstones, and to his own observations on the practical porosity of some basic igneous rocks. Allusion was also made to the fact that the application of the undulatory theory to the optical phenomena exhibited by transparent bodies involved the assumption of molecular interspaces.

General McMahon then alluded to the law that governs capillary flow, and mentioned that pressure gauges set up in the Severn tunnel 190 feet from the surface, showed that the actual pressure of the water in the rocks at the tunnel exactly corresponded to the calculated pressure, being about 80lbs. per square inch; a fact that proved that the water permeating the rocks acted in one unbroken head. He then alluded to the experiments of Poiseulle, who had shown that capillary flow was increased by heat; water at 45° Centigrade flowing through capillaries three times faster than water at zero Centigrade.

The capacity of water to hold carbon dioxide and oxygen in solution was next alluded to. Water at 60° is capable of taking up rather more than its own volume of carbon dioxide, and meteoric water contains two cubic inches of oxygen and one cubic inch of carbon dioxide per gallon. As rain-water passes downwards into the earth the percentage of oxygen is reduced and that of carbon dioxide increased. He explained how this fact, as pointed out by Prof. Heddle in a paper read before the Royal Society, Edinburgh, accounted for the ferrous oxide in olivine being removed as carbonate, when rocks were acted on at some depth, but converted into magnetite, or ferric oxide, when subjected to aqueous agencies nearer the surface.

Carbonated water is capable of decomposing the silicate of magnesia, and of carrying off some of the magnesia in the form of carbonate, as proved experimentally by Bischof. Profs. W. E. and R. E. Rogers further showed that digestion in simple water for three days was sufficient to remove an appreciable amount of magnesia from such minerals as hornblende. General McMahon stated that he obtained a similar result by the digestion of powdered olivine in distilled water heated to about 100° F.

The formula for olivine is $2MgO, 2FeO, SiO_2$, and it was explained in detail how the removal of the ferrous oxide, a portion of the magnesium silicate, and the absorption of water converted olivine into serpentine. The formula for the latter is $3MgO, 2SiO_2, 2H_2O$.

Taking enstatite and malacolite as types of the rhombic and monoclinic pyroxenes, and tremolite as that of the amphiboles, he explained how the lime was removed and the percentage of magnesia was increased. Whilst olivine, the predominant mineral, was parting with some of its magnesia, the silica set free in the pyroxene by the decomposition of the silicate of lime combined with this surplus magnesia on its exit from the olivine and a gradual conversion of pyroxene into serpentine was the result.

II.—The "Manure" Gravels of Wexford.[1] By Alfred Bell.

SINCE the last report the explorations carried out in the area of the gravels, in Ballybrack, Balscaddin, and Balbriggan Bays, in Larne Lough and the vicinity, and Portrush, have much augmented the material previously accumulated.

The exigencies of building and road-making have practically obliterated the most prolific portion of the drifts in Ballybrack (or Killiney) Bay and the deposit at Portrush, the only traces of the shell-bed at the latter place occurring between the rocky masses on the shore above high-water mark. Fortunately, previous to these operations a quantity of material was obtained by the reporter, and a list of about 120 species will be given in the sequel, wherein a brief notice of the principal deposits will be found, with lists of fossils obtained by the writer and previous observers. The line of research to which an examination of the fossils has led is to the effect (1) that the so-called Lower, Middle, and Upper drifts in Ballybrack Bay have no connection whatever with the equally so-named deposits in the English and Welsh areas, but are a continuation northward of the Cotentin—St. Erth-Wexford sea-bed referred to in the second report, 1888, further traces of this extension obtaining in the glacial clays of the Isle of Man, *Nassa reticosa*, among other Pliocene mollusca, occurring in the northern portion of the island.

Coeval with the Pliocene fauna of Wexford, Ballybrack, and the Isle of Man are numerous species of northern origin, and examination of these suggests a Scandinavian rather than an American or Greenlandic origin—a suggestion intensified by the presence of a true Scandinavian fauna in several parts of the Scottish lowlands from the Clyde to the Forth and the eastern side of Scotland; and it is not perhaps too improbable to suppose that the Pliocene shells obtained by Mr. T. F. Jamieson in Aberdeenshire came by this route rather than from the Suffolk crag-beds. From the absence of the Pliocene fauna northward of the before-quoted localities on the Irish coast and Manxland, the writer is of opinion that the Irish Channel was closed when the strata at these places were being accumulated, and

(2) That the Severn drifts from Worcester northwards into Lancashire are of much later date, not originating till the south of Ireland was separated from the continent. And lastly, that the faunas obtained both in England and Ireland, near Dublin and Wicklow, at elevations of 1000 feet and more, are "remanie" and not in their original habitat.

An examination of the gravelly and shelly sand dredged from the Turbot bank in the Irish Sea has long convinced the writer that the accumulation is in the main of post-glacial age, intermixed with a few recent forms, easily distinguished from the older species by their appearance. The material is very rich in other groups than the molluscan, catalogued already by Mr. Hyndman. Of all these he purposes giving a list.

[1] Third Report read in Section C., Geology, at the Meeting of the British Association, Newcastle-upon-Tyne, 1889.

It may be well to say that the matter first examined was sent to the writer some years back by Mr. E. Waller, who worked with Mr. Hyndman on the mollusca; and, secondly, from a quantity of Mr. Hyndman's own washings, placed at his disposal by Mr. S. A. Stewart, of Belfast.

REVIEWS.

I.—Report on the Geology of the Rainy Lake Region. By Andrew C. Lawson, M.A., Ph.D. Annual Report of the Geological and Natural History Survey of Canada for 1887. Part F.

THE progress of knowledge with reference to the foliated crystalline rocks has been very rapid of late years, and accompanied by incidents that may almost be described as sensational. One such incident was the announcement by Mr. Lawson at the meeting of the International Geological Congress, held in London, that the Laurentian rocks in the neighbourhood of Rainy Lake were intrusive into a series consisting of schists, diabases, felsites, agglomerates, and greywackes.

Up to the time of the announcement of Mr. Lawson's discoveries it had been supposed that the Laurentian rocks were always older than the rocks in contact with them, and the hunters after that geological Will o' th' wisp, the primitive crust of the earth, were beginning to feel tolerably satisfied that they had at last caught the object which had hitherto eluded their grasp. It was seen at once that Mr. Lawson's discoveries reopened the whole Laurentian question, and made it possible if not probable that the so-called Laurentian system was a complex, and that the most characteristic rocks of the system—the gneisses—were plutonic igneous rocks, actually of later date than rocks which have been formed by such agencies as are now in operation at the surface of the earth.

We have in the Memoir before us the details of Mr. Lawson's work, illustrated by an admirable map of the Rainy Lake region, and by photographs of actual junctions. A study of this Memoir will leave no doubt in the mind of any geologist that Mr. Lawson has fully established his main point, which is this—that over an area of several thousand square miles the gneisses hitherto[1] regarded as Laurentian have consolidated as such from a plastic magma long after the formation of the rocks which encircle them. As this point is one of great importance we will give a somewhat detailed account of Mr. Lawson's work.

The rocks into which the Laurentian is intrusive are divided by the author into two series—the Coutchiching and the Keewatin. The earlier or Coutchiching series consists mainly of mica-schists and granulitic gneisses. The dominant constituents of the mica-schists are granulitic quartz and biotite. The gneisses differ from

[1] The term Laurentian is still retained for these rocks in this Memoir.

the mica-schists principally in containing felspar. The structure of both rocks is the same. The original rocks are supposed by the author to have been of sedimentary origin.

The Keewatin series is much more variable in character. It includes diabases, hornblende-schists, soft fissile green schists, conglomerates, sericite schists, felsitic schists (altered quartz-porphyries) greywackes and volcanic tuffs.

The "bedded traps or greenstones" give the character to this series. They have suffered more or less alteration (*a*) by metasomatic processes, (*b*) by dynamic action. Those which have been affected by the first set of processes only preserve the original structure so as to leave no doubt as to the original characters of the rocks. Some have the ophitic structure of diabases, others the granular structure of gabbros. Those which have suffered dynamic metamorphism have lost their original structure to a greater or less extent, and taken on that of a schistose or foliated rock. The constituents of these more or less altered basic igneous rocks are felspar, pyroxene, fibrous and compact hornblende, titaniferous iron ore, apatite, leucoxene, zoisite, epidote, chlorite, calcite, and quartz. The rocks are described by the author under such names as uralitic and saussuritic gabbro, uralitic diabase and porphyritic diabase. It is evident from the detailed descriptions with which the Memoir abounds that the rocks are similar to varieties of greenstone occurring in the West of England.

The hornblende-schists are regarded by the author as being in part altered massive rocks, and in part altered pyroclastic rocks of basic composition. The felspathic varieties approach diorites in structure and composition. Dynamic action has certainly determined the structure of these rocks, but it has operated before the final stages of recrystallization were complete, for the individual constituents do not show any of those effects of pressure which are so common in the schistose diabases.

The soft green fissile schists are usually bedded and are probably metamorphosed pyroclastic rocks.

The matrix of the conglomerates is a dark green chloritic or hornblendic schist. The pebbles are often well-rounded and reach as much as a foot in diameter. They consist of saccharoidal quartz, felsite, quartz-porphyry and granite. It will be noted that pebbles of Laurentian gneiss are conspicuous by their absence.

The sericitic and felsitic schists are merely altered quartz-porphyries. They are associated with acid volcanic tuffs and agglomerates.

In addition to the volcanic rocks which form the bulk of the series there are grits or greywackes, which consist, for the most part, of ordinary sedimentary material.

Owing to the enormous jamming together which the rocks have undergone it is not possible to estimate the thickness of the Keewatin series. It must, however, have amounted to many thousands of feet. Their general disposition is that of a sharply folded trough, sinking down into the gneiss which flanks it on either side. The hornblende-schists and diabases form the lower, and the felsites and felsitic schists the upper portions of the series, according to the author.

Now the Laurentian rocks of the district under consideration occur in "central circular or oval areas." Each area is isolated at the surface from its neighbours by a belt of Keewatin or Coutchiching rocks. In most cases the breadth of this belt is very small in comparison with the diameter of the Laurentian areas. The author has traced out the boundaries of three of these areas, which he names the Obabicon, the Sabaskong, and the Stanjikoming areas respectively. He has also partially mapped out two other large areas which lie to the N. and N.E. of the Stanjikoming area. To give some idea of the scale on which the phenomena are developed, we may mention that the Stanjikoming area measures thirty-two miles from N. to S. and forty-six from E. to W. It is separated from the Sabaskong area on the N.W. by a belt of Keewatin rocks about three miles in width, and from the Lake Harris area on the N. by a belt of the same rocks about 4½ miles in width.

The contact of the two groups of rocks is well exposed at many points, especially on the shores of the numerous lakes. It is everywhere the same, and leaves no doubt as to the relative ages of the rocks. The gneisses are intrusive. They send out apophyses into the adjacent rocks, and contain included fragments, often in immense numbers. The apophyses are sometimes in the form of sheets running parallel to the schistosity or bedding of the surrounding rocks; sometimes in the form of veins or dykes cutting across the bedding. The rocks in contact with the Laurentian are not always the same; sometimes they are the hornblende-schists which form the basal members of the Keewatin series; sometimes the felsitic rocks which constitute the higher members of the same series, and sometimes the biotite-schists of the Coutchiching series.

The Laurentian rocks are divided by the author into two principal groups depending on the amount of quartz which they contain, and termed respectively syenitic and granitic gneisses. Thus we have hornblende-syenite gneiss, biotite-syenite gneiss, hornblende-granite gneiss, and quartzose biotite gneiss. The constituents are orthoclase, microcline, plagioclase, quartz, biotite, pyroxene, hornblende, sphene, epidote, zircon, magnetite. The hornblende frequently contains cores of pyroxene, and the author is inclined to regard the whole of it as paramorphic after pyroxene. The general microscopic structure is granitic, and crush phenomena are as a rule entirely absent. Foliation is generally well marked, but massive areas may sometimes be observed. The different varieties shade into each other.

In the Stanjikoming area the syenitic gneisses occur on the borders; the quartzose biotite-gneisses in the central area.

One striking feature which is brought out by an extended survey of the Laurentian areas is the concentric character of the foliation. At the margins the strike of the foliation is parallel to the junction; in the interior it is concentric with reference to one or more centres.

The author has paid special attention to the phenomena of the inclusions. These inclusions are found, not only near the margins of the Laurentian areas, but also in the central portions. They vary in size from that of one's fist to that of a house and even larger. Near the junction a definite connection between the inclusions and the surrounding rocks may be traced. Thus, at the contact with hornblende-schist, the inclusions consist of hornblende-schist, and at the contact with the Coutchiching series they consist of rocks derived from that series.

The inclusions are sometimes angular and sharply separated from the gneiss, at other times they are lenticular and blend more or less gradually with the surrounding rock. The elongated inclusions are arranged with their longer axes parallel to the general foliation. All the facts go to show that the parallel arrangement of the inclusions and the foliation of the gneiss are fluxion phenomena. Certain banded gneisses are regarded by the author as due to a stretching of an intimate mixture of inclusions with the gneissic magma. The memoir is illustrated by photographs of portions of the gneiss which are rich in inclusions, and one of these (plate vi.) bears a most striking resemblance to Fig. 2, Plate XIV.[1] Geol. Mag. Dec. III. Vol IV. 1887.

In addition to the points above referred to, the Memoir contains much interesting matter. Thus it treats of the relation between topography and geological structure, the petrographical characters of numerous intrusive granites, the distribution and character of certain later basic dykes, and the glacial phenomena of the district.

As regards the origin of the Laurentian rocks the author propounds the theory that they represent the fused floor on which the Coutchiching and Keewatin rocks were deposited, and to a certain extent also of fused portions of these rocks. He insists, however, strongly on the point that whatever may have been the origin of the magma, the minerals of which the Laurentian rocks are composed, and the structures which these rocks possess, owe their origin to causes operating after the formation and folding of the rocks with which they are in contact.

In speaking of the topography of the Laurentian areas he says "it is remarkably flat and devoid of prominent elevations, although the surface in detail is extremely uneven and hummocky or mammillated. It presents for the most part the glaciated surface of the rocks either quite bare or covered only by forests and forest loam. The plateau abounds in lakes, which lie in rocky basins." This description will be thoroughly appreciated by all those who are acquainted with the Archæan topography of the N.W. of Scotland.

J. J. H. T.

[1] This plate illustrates a paper by the reviewer "On the Origin of Certain Banded Gneisses."

II.—Einige Bemerkungen ueber die Jura-Ablagerungen des Himalaya und Mittelasiens. Von S. Nikitin. Neues Jahrbuch für Mineralogie, etc., 1889, Bd. II. pp. 116–145.

Remarks on the Jurassic Strata of the Himalaya and Middle-Asia. By Prof. Nikitin of St. Petersburg.

THE principal development of Jurassic beds in the Himalaya is on the north-eastern slopes of the southern crystalline chain in the neighbourhood of Spiti and Niti, where, resting on strata referred to the Rhætic and Lias, are the well-marked dark crumbling shales known as the "Spiti shales." These shales are filled with phosphatic concretions, which have yielded a rich fauna, principally of Ammonites, which have been studied and described by Oppel, H. F. Blanford, Stoliczka, Waagen, and Neumayr. Very different opinions have been expressed by these authors as to the relations of the Ammonites to those in the Jurassic rocks of Europe and of Cutch, and consequently as to the relative geological horizon of the rocks themselves; but they have been generally reckoned as of the age of the Kelloway and Oxford Clays, and supposed, more particularly by Neumayr, to be related to those of the Russian and Polar Jura. Prof. Nikitin has lately studied the two most important collections from the Himalaya; that of Schlagintweit at Munich, and of Strachey, in the British Museum, and in this paper he discusses the characters of the Ammonites and other fossils, and gives reasons for regarding them as belonging to a younger horizon than hitherto supposed. The following are the conclusions to which he has arrived: (1) The fauna of the Spiti shales stand nearest to that of the Tithon and Kimmeridge of Western Europe. Most of the Ammonites which up to now have been considered as Kelloway and older forms represent much younger types. (3) The differences between the fauna of Spiti and that of Cutch may be easily explained on the supposition that the fossil-bearing beds in the two regions do not represent synchronic horizons. (4) The Himalayan Jura shows a far more significant relationship to the Tithon of Southern Europe than to any Russian Mesozoic formation. (5) The fauna of the Russian Jura on the other hand is more intimately united to that of Cutch than to that of the Himalayan Jura. (6) The assumed geological and geographical connection of the Himalayan and Indian Jura with the Russian Jurassic ocean, through the supposed Tarim basin, the Altai region, and the great polar ocean, is as yet by no means proved. On the other hand, there are many indications in favour of the connection having taken place through the Amour region, Bokhara, Afghan Turkestan, Khorasan, and the Aral-Caspian depression.

III.—Fossil Fishes from the Devonian of Belgium.

"Recherches sur les Poissons des Terrains Paléozoiques de Belgique." By Maximin Lohest. Ann. Soc. géol. Belg., vol. xv. (1888), Mémoires, pp. 112–196, pls. ii.–xi.

THE remains of fishes discovered in the Devonian formation of Belgium are all of a very fragmentary character, consisting chiefly of detached teeth, portions of bones, and isolated scales;

but their determination is interesting on account of their intimate association with truly marine fossils. Until the appearance of the present work only four specimens had been critically examined and described (*Holoptychius Omaliusi*, *Palædaphus insignis*, *Palædaphus devoniensis* and *Byssacanthus Gosseleti*); and palæichthyologists are indebted to M. Lohest for the care and perseverance with which he has collected, examined, compared, and described all available material.

A brief introduction summarizing the present state of knowledge of the Belgian Devonian fish-fauna is followed by the systematic and descriptive part, which occupies fifty pages, and is illustrated by eleven plates. Eight genera and fourteen species are determined, and most of the descriptions are accompanied with good figures drawn by the author. Two forms of teeth from Strud are assigned to *Dendrodus*, the one believed to be identical with certain gently curved teeth commonly associated with *D. sigmoides* and now named *D. Traquairi*, the other regarded as hitherto unknown and named *D. Briarti*. *Lamnodus* is accepted as a sub-genus of *Dendrodus*, and an imperfect tooth from the Upper Famennian of Liège is described as *L. minor*, sp. nov.; the genus *Cricodus* receives a doubtful portion of dentary, named *Cricodus*? *Agassizi*, sp. nov.; and then follows a long section upon *Holoptychius* and its Belgian representatives. M. Lohest has studied the fine specimens in the British Museum, besides others at Edinburgh, and treats of the squamation, especially, in considerable detail. As the result of his researches, he recognizes great variation in the scales of different parts of the body, but considers that detached examples are usually specifically determinable when their outline is distinct; for the scales of corresponding parts in the various species are almost identical in shape and proportions, only differing in thickness and the arrangement of the external ornamentation. Some isolated bones of the genus are first noticed, and then follows a section upon the supposed teeth of *Holoptychius*, which appear to be identical with so-called *Lamnodus* previously described. The typical *H. nobilissimus* is regarded as not certainly met with in Belgium, and the author considers that both Agassiz and the British Museum include under this species some scales of forms that are truly distinct. To us, however, it appears that the scales now named *H. Dewalquei* can be so closely paralleled by examples found in close association with the true *H. nobilissimus* of Clashbennie that there is no justification for their specific separation. Several fine specimens of these scales are figured; and an equally good series of very thin scales, exhibiting a nearly similar ornament, is described and figured as *H. inflexus*, sp. nov. Other scales are identified with the well-known Scottish species, *H. giganteus* and *H. Flemingi*. A brief discussion of *Glyptolepis* results in the conclusion that its scales only differ from those of *Holoptychius* in their comparative tenuity; and some small specimens from Strud are assigned to *G. Benedeni*, sp. nov., and *G. radians*, sp. nov.

After the description of the "Cyclodipterines," the arrangement of the teeth in the mandible of the several genera is discussed, and it is concluded that here may be found diagnostic generic characters. We venture, however, to think that the differences in the illustrative diagrams are due merely to their being based upon imperfect evidence; and, so far as dental arrangement is concerned, there seems to be no essential difference between the several genera under comparison. When the large teeth are undergoing replacement, the new one is always for a time placed by the side of the old one as indicated in the diagram of "*Lamnodus*"; while it seems most probable (as first suggested by Traquair) that "*Bothriolepis favosus*" is truly referable to *Cricodus*, thus disproving the diagram assigned to the mandible of that genus.

A few ornamented small rhomboidal scales, from Strud and Modave, M. Lohest ascribes to the *Glyptolæmus Kinnairdi* of Dura Den: and several typical, though imperfect, scales of *Phyllolepis* are named *P. undulatus*, sp. nov., and *P. Corneti*, sp. nov. Other scales, very suggestive of *Phyllolepis*, are also described, and on account of their pentagonal outline are believed to indicate a distinct new genus, *Pentagonolepis*, of which the type-species is termed *P. Konincki*. The characters of the scales lead M. Lohest to regard this genus as one of the Lepidosteoid Ganoids; but all known facts concerning the evolution of the fishes render such a determination most improbable.

The fossil fishes thus enumerated obviously indicate an Upper Old Red Sandstone fauna; and one of the formations yielding them—the "schistes d'Evieux"—is regarded as apparently intermediate in age between the well-known sandstones of Elgin and Dura Den. Lists of species are given; and there is a long, and somewhat inconclusive, discussion as to whether the fishes lived in fresh- or salt-water. Other general considerations, both geological and palæontological, are also treated in the final section of the memoir; and the physical geologist, equally with the ichthyologist, will find several items of interest. A. S. W.

IV.—Upper Cretaceous Fish-remains from Manitoba.

"Contributions to Canadian Palæontology," vol. i. pt. ii. (Geol. Surv. Canada, 1889), pp. 191–196, pl. 26, figs. 5–9. By J. F. Whiteaves, F.G.S.

THE known range of three typical genera of Upper Cretaceous fishes is extended by the recent discovery, in the Niobrara Beds of Manitoba, of some fragmentary, though interesting, remains described by Mr. Whiteaves. A small dental crown of *Ptychodus* is doubtfully determined as new and named *P. parvulus*; but its dwarfed dimensions and comparative narrowness may possibly be explained by its pertaining to the median series of the upper jaw. Two teeth of *Lamna* described as *L. manitobensis*, sp. nov., are very closely related to *Lamna macrorhiza*, and perhaps only a variety of the latter. A small slab of shale exhibits portions of jaws and teeth of *Enchodus*, identified with the Niobrara form (*E. Shumardi*) already discovered in Nebraska; but, as shown by skulls in the British

Museum (Proc. Geol. Assoc. vol. x. p. 315, pl. i. figs. 5, 6), the bone named maxilla is truly the premaxilla, while the so-called premaxillary tooth pertains to the palatine element. Numerous scales of *Cladocyclus* not only add this genus to the list from Manitoba, but likewise appear to be referable to a species known from Nebraska, namely, *C. occidentalis*, Leidy. A. S. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 20, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.

The Secretary announced that a series of specimens from the line and the neighbourhood of the Main Reef, East and West of Johannesburg, Witwatersrand Gold Fields, had been presented to the Museum by Dr. H. Exton, F.G.S., and a letter from that gentleman in explanation of them was read. In this Dr. Exton stated that all but one of the mines represented were on the main reef of the district, which has a general direction east and west, its dip varying generally from 45° to 80°. South of the main reef and parallel to it at a distance of 15–20 feet is a narrow reef known to the miners as the "south leader," and generally much richer than the main reef. The gold-bearing deposits consist of conglomerates, specimens of which, and of a purplish-red rock which forms a jagged ridge at some distance north of and parallel to the so-called reef, were contained in the collection.

1. "On the Occurrence of the Striped Hyæna in the Tertiary of the Val d'Arno." By R. Lydekker, Esq., B.A., F.G.S.

A portion of the left maxilla of a Hyæna, in the British Museum, containing the entire carnassial, the hinder half of the third premolar, and traces of the inner extremity of a molar, was referred by the author in 1885 to *H. striata*, and provisionally regarded as of Pleistocene age, but subsequently concluded to have been of Upper Pliocene age. The author has also referred a right upper carnassial of a Hyæna from the Red Crag to the same species, on the supposition that Prof. Gaudry's reference of *H. arvernensis* to *H. striata* was correct. In the present case, Dr. Weithofer has concluded that *H. arvernensis* is entitled to rank as a valid species, and has accepted the author's determination of the Red-Crag form, thereby implying that the identification of the latter with *H. arvernensis* was erroneous. Dr. Weithofer also states that all the specimens from the Pliocene of the Val d'Arno which have come under his notice are more nearly allied to the Crocutine group.

In the present paper, measurements of the recent, Red Crag, and Val d'Arno specimens referred by the author to *H. striata* were given, and the differences shown to be within the limits of individual variation, whilst the actual contour of the teeth corresponded, leading the author to maintain the correctness of his original determination.

After comparison of the British Museum specimen with the upper jaw of Hyænas from the Val d'Arno, figured by Dr. Weithofer, it was shown that the former specimen was distinct from *H. robusta* (which latter is allied to *H. felina* of the Siwalik Hills), whilst a nearer resemblance, though with well-marked specific difference, was made out with *H. topariensis*, which was in turn observed to be closely allied to, if not identical with, *H. Perrieri*.

It was observed that *H. arvernensis* could be with difficulty distinguished from *H. brunnea*, and that both of these were nearer to *H. striata* than to *H. crocuta*, whilst *H. Perrieri* appeared to connect them with the latter.

2. "The Catastrophe of Kantzorik, Armenia." By Mons. F. M. Corpi. Communicated by W. H. Hudleston, Esq., M.A., F.R.S.

The village is 60 kil. from Erzeroum, and 1600 mètres above sea-level. Subterranean noises and the failure of the springs had given warning, and on the 2nd of August, 1889, part of the "Eastern mountain" burst open, when the village, with 136 of its inhabitants, was buried in a muddy mass.

The author described the district as formed of Triassic, Jurassic, and Cretaceous strata, subsequently broken up and torn by granitic, trachytic, and basaltic rocks, which overlie or underlie the Secondary rocks, according to the nature of the dislocation.

The flow was found to have a length from east to west of 7–8 kil., with a width ranging from 100 to 300 mètres, and the contents were estimated at 50,000,000 cubic mètres. It appeared as a mass of blue-grey marly mud, which, after the escape of the gases, solidified at the top; the inequalities projected to the extent of 10 mètres. The site of the village was marked by an elevation of the muddy mass, some of the débris of the houses having been carried forward. The lower part of the flow was still in a state of motion, and carried forward balls of marly matter.

It was difficult to approach the source of this flow on account of the crevasses in the side of the mountain. An enormous breach served as the orifice for the issue of the mud, which emitted, it was said, a strong odour. The violent projection of this marly liquid and "incandescent" (?) mass had carried away a considerable portion of the flanks of the mountain, whose débris might be recognized on the surface of the flow by the difference of colour. Great falls were still taking place, throwing up a fine powder which rose into the air like bands of smoke. There were also fissures and depressions of the ground at other localities in the neighbourhood.

3. "On a new Genus of Siliceous Sponges from the Lower Calcareous Grit of Yorkshire." By Dr. G. J. Hinde, F.G.S.

The author referred, in the first instance, to the discussion as to the nature of certain renuline bodies occurring in the Corallian of Yorkshire and elsewhere. Although regarded of late years as the globate spicules of a siliceous sponge, the apparent absence of acerate and forked spicules in association therewith has always presented a difficulty. Recently the author has recognized in specimens from

Scarborough certain siliceous sponges which seem to be formed entirely of globates. In outward appearance the sponge is upright, and palmate or fan-shaped, the largest being 140 millim. in height. The wall is 14 millim. thick, and consists of plates which anastomose so as to form a labyrinthine structure, and are perforated regularly by oval slits. The laminated walls are composed entirely of small reniform spicules (globates), well seen where secondary crystallization has not fused them together. The globates, like those of *Geodia*, are built up of fibres radiating from the centre, and terminating on the outer surface in nodose ends, which causes a spotted appearance.

The exceptional character of these sponges consists in their having the siliceous skeleton composed entirely of globates. The nearest living form is *Placospongia*, in which both the axis and the dermal crust are formed of globates with an interspace built up of numerous pin-like spicules. Assuming the absence of pin-like spicules in the Scarborough fossil, the differences are more than generic. The name *Renulina*, given by Blake to the globates, having been preoccupied, the author proposed that of *Rhaxella* for the genus, and described the sponge from the Lower Calcareous Grit as *R. perforata*, sp.n.

II.—Dec. 4, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On Remains of Small Sauropodous Dinosaurs from the Wealden." By R. Lydekker, Esq., B.A., F.G.S.

The author first noticed some teeth from the Wealden of Sussex and the Isle of Wight, provisionally referred by Mantell, and subsequently by Sir R. Owen, to *Hylæosaurus*, which he had made the type of a species of *Pleurocœlus*. He then described the imperfect centrum of a dorsal vertebra from the Wealden of Cuckfield, preserved in the British Museum, and a somewhat larger imperfect vertebra obtained from the Wealden of Brook, Isle of Wight.

In the absence of any evidence in favour of a contrary view, he proposed provisionally to refer the vertebra to *Pleurocœlus valdensis*, a name which he had given to the form represented by the teeth in a paper published in the GEOLOGICAL MAGAZINE for the current year. He stated that they afforded absolutely conclusive evidence of the occurrence in the English Wealden of a diminutive Sauropodous Dinosaur, which was the contemporary of the huge *Hoplosaurus* and the still more gigantic *Pelorosaurus*, and that they also served to increase the evidence as to the similarity of the Dinosaurian fauna of the Upper Jurassic of North America to that of the Upper Jurassic and Lower Cretaceous of Europe.

2. "On a Peculiar Horn-like Dinosaurian Bone from the Wealden." By R. Lydekker, Esq., B.A., F.G.S.

Among a series of vertebrate remains sent from the Dorsetshire County Museum to the British Museum, there is an imperfect, stout, short, cone-like bone from the Wealden of Brook, Isle of Wight. It appears to present a close resemblance to the horn-cores of the Dinosaur described by Prof. Marsh as *Ceratops*.

The author did not regard the specimen as affording conclusive evidence of the existence in the Wealden of a large Dinosaur furnished with horn-like projections on the skull like those of the American *Ceratops*, but suggested that such might really prove to be its true nature.

3. "The Igneous Constituents of the Triassic Breccias and Conglomerates of South Devon." By R. N. Worth, Esq., F.G.S.

During the investigation several hundred fragments were examined, the largest occurring at Teignmouth, between which place and Dawlish the breccias are most varied in composition, and contained the greatest proportion of granitoid rocks. The igneous fragments were thus divided:—I. Granites; II. Felsite group: *a*, non-schorlaceous, *b*, schorlaceous; III. Andesitic group: IV. Miscellaneous. Of these, including in all 76 varieties, I., II. *b*, and IV. are plainly of Dartmoor origin in gross, the schorlaceous and contact-altered rocks having belonged to the outer or to an upper zone; III. can for the most part be identified with the *in-sitû* "felspathic traps" of the neighbourhood. The non-schorlaceous division of II. differs but little from Dartmoor elvans; some may have been surface-portions of felsitic dykes, or even fragments of felsitic lavas. The igneous fragments of the breccias, as a rule, are not much altered structurally; they are of local origin.

The large blocks indicate the vicinity of high land abutting on a shore-line. Of this high land Dartmoor is a relic. The transporting power of water was perhaps supplemented by a glacial climate and volcanic activity. De la Beche considered that igneous action accompanied the earliest "red-rock" deposits. The "felspathic traps" are known to be both antecedent to and contemporaneous with the breccias, and there is evidence which points to their being comprised within the period of igneous activity represented by the Dartmoor elvans. The author says that there is a preponderance of volcanic over plutonic igneous rocks, and thinks that the existing remnants of "felspathic traps" are not sufficient to supply the quantity. He suggests that they must have come from an upper portion of Dartmoor.

In conclusion, the author considered that he has shown that the igneous materials are of local origin, and that they consist of granites, felsites, and volcanic types, ranging from andesites to basalts; that the few igneous fragments not hitherto assigned to *in-sitû* rocks are yet of a similar character; that the conditions under which the "felspathic traps" occur *in sitû* lead to the inference that they are volcanic phenomena which probably represent the final phase of the igneous activity of the Dartmoor region. Lastly, he expresses his opinion that the elevation of Dartmoor and the associated igneous phenomena took place at a period not earlier than the Permian.

4. "Notes on the Glaciation of Parts of the Valleys of the Jhelam and Sind Rivers in the Himalaya Mountains of Kashmir." By Capt. A. W. Stiffe, F.G.S.

After referring to the previous writings of Messrs. Lydekker, Theobald, and Wynne, and Col. Godwin-Austen, the author gave an account of his observations made during a visit to Kashmir in 1885, which appeared to him to indicate signs of former glaciation on a most enormous scale.

A transverse valley from the south joins the Sind valley at the plain of Sonamurg, and contains glaciers on its west side. These, the author stated, filled the valley at no remote period, and extended across the main Sind valley, where horse-shoe-shaped moraines, many hundred feet high, occurred, and dammed the river, forming a lake of which the Sonamurg plain was the result. The mountains which originated the above glaciers were described as being cut through by the Sind river, and the rocks of the gorge were observed to be striated, whilst rocks with a moutonnée appearance extended to a height of about 2000 feet.

The whole of the Sind valley was stated to be characterized by a succession of moraines through which the river had cut gorges, whilst the hill-sides were seen to be comparatively rounded to heights of 2000 feet or more.

The author had also formed the opinion that at Bâramulla the barrier of a former lake occupying the Kashmir valley was partly morainic, before reading Prof. Leith Adams's view of the glacial origin of some of the gravels of this point.

The whole valley of the Jhelam from this point to Mozufferabad showed extensive glacial deposits, which had been modified by denudation and by the superposition of detrital fans, widely different in character from the glacial deposits. Below Rampoor the valley was thickly strewn with enormous granite blocks resting upon gneiss, and the author believed that they had been transported by ice.

In conclusion, it was noted that the existing torrential stream had further excavated the valley since Glacial times and, in places, to a considerable depth.

OBITUARY.

JOHN BALL, F.R.S., F.L.S., M.R.I.A., &c.

Born 20th August, 1818; Died 21st October, 1889.

The sudden death of Mr. John Ball has removed from amongst us a man whose name will be remembered with veneration so long as Alpine geology and botany and mountaineering pursuits retain any of their present interest. As the eldest son of a distinguished lawyer—the Rt. Hon. Nicholas Ball, Attorney-General for Ireland, and subsequently Judge of the Court of Common Pleas—Mr. Ball was naturally destined for the legal profession, and after a brilliant career at Cambridge, he was called to the Irish bar in 1843. He however soon turned his attention from law to politics, and served for some years as Assistant Poor Law Commissioner for Ireland, a post which he resigned on his election in 1852 as Member for Carlow. His Parliamentary career, though brief, was distinguished. The statesmanlike foresight that led him then to advocate the principle of tenants' compensation for disturbance, and the courage with which he sacrificed his Irish popularity by his defence of the extension of the Income-tax to Ireland, won for him the confidence of the leaders of his party, and led to his appointment in 1855 as Under-Secretary for the Colonies in Palmerston's first administration. But Mr. Ball's defeat at Limerick in 1858 induced him to abandon politics for science.

It was about this time that the Alpine Club was started, and though he was not one of its original founders, Mr. Ball's thorough knowledge of the Alps, and his brilliant exploits there, led to his election as its first President. It is almost impossible now to realize the difficulties with which Mr. Ball had to contend in his early Alpine explorations. The race of skilled mountaineers who now do most of the work of an ascent was not then in existence; though a local guide was indispensable, he usually hindered instead of helping, and was a positive danger on snow or ice; thus in Mr. Ball's ever-memorable passage of the Schwarzthor in 1845, the whole of the difficult work among the seracs of the Schwarz glacier devolved on him; or, again, in the first ascent of the Pelmo, the guide was left behind, too frightened to proceed, while Mr. Ball fought his way to the summit alone.

But it is probably not as a climber that Mr. Ball will be best remembered; others coming after him have reaped the rewards of his labours, and with a better race of guides have gained a wider popular renown by the ascent of better known peaks, or of those around which some striking tragedy has thrown the halo of romance. But while Mr. Ball climbed "he used his head as well as his heels," to quote an old saying of his, and he always studied the botany and geology of the districts he traversed. The former was his favourite science, and as every one knows who has used his Guide, he was as familiar with the local plants as with the local passes. In working out his well-known theory of the origin of the Alpine flora,[1] he made numerous visits to the Pyrenees and the Balkans, and others to the Andes and the Atlas; a lengthy list of memoirs and papers testifies to the ardour of his botanical studies, while some of his results are of as much interest to geologists as botanists. In the controversies over the theories of glacier motion and the glacial origin of lake-basins, Mr. Ball's intimate acquaintance with the Alpine glaciers gave his utterances[2] exceptional weight; his paper on "Soundings Executed in the Lake of Como"[3] seems to have settled the question as far as that lake is concerned. His papers on glacier motion are no less marked by the trenchant criticisms of the theories of Moseley and Croll than by the clearness with which he recognized the fundamental differences between glacier and lake ice.

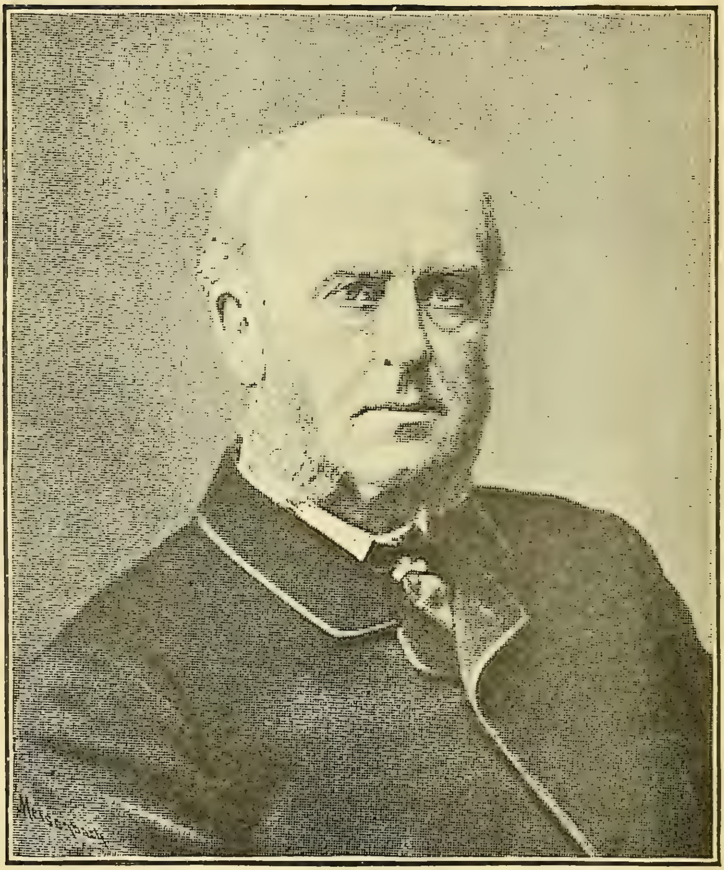
Though others may have made more striking first ascents, or have left a deeper mark in Alpine geology, there seems to be no question that in his knowledge of Alpine topography, Mr. Ball stood absolutely without a rival. Mr. Ball knew the Alps as no other man ever knew them. His great "Alpine Guide"[4] has rendered invaluable service to all subsequent work on the geography of the Alps. It is not till one has tested this work in some unfrequented region, and compared it with other guide books of the same period, that one can realize with what marvellous instinct its author had seized all the salient features in the district. It is hoped that a new and revised edition of this Guide will be prepared by the Alpine Club, as to give Mr. Ball's greatest work a new lease of usefulness would be the most appropriate memorial to one of the earliest of Alpine explorers and the greatest of scientific mountaineers. J. W. G.

[1] "On the Origin of the Flora of the European Alps," Proc. Geogr. Soc. new ser. vol. i. 1879, pp. 564-88.

[2] "On the Formation of Alpine Valleys and Alpine Lakes," Phil. Mag. vol. xxv. 1863, pp. 81-103. "On the Formation of Alpine Lakes," Phil. Mag. vol. xxvi. 1863, pp. 489-502. "On the Cause of the Descent of Glaciers," Phil. Mag. vol. xl. 1870, pp. 1-10. "On the Cause of the Motion of Glaciers," Phil. Mag. vol. xli. 1871, pp. 81-87.

[3] Geol. Mag. Vol. VIII. 1871, pp. 359-63.

[4] Western Alps, 1863; Central Alps, 1864; Eastern Alps, 1868.



Yours very truly
Archd Geikie

THE

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No. II.—FEBRUARY, 1890.

ORIGINAL ARTICLES.

I.—Eminent Living Geologists.—No. 6.

Professor Archibald Geikie, LL.D., F.R.S. L. & E.,

DIRECTOR-GENERAL OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM.

(WITH A PORTRAIT.)[1]

DOCTOR ARCHIBALD GEIKIE was born in Edinburgh in 1835. He was educated at the Royal High School—the most famous of the many celebrated scholastic institutions of the "Modern Athens," and at Edinburgh University. He became an Assistant on the Geological Survey of Scotland in 1855, and in 1867, when that branch of the Survey was made a separate establishment, he was appointed Director. A few years later—in 1871—he was elected to fill the Murchison Professorship of Geology and Mineralogy in the University of Edinburgh, when the chair for these subjects was founded by Sir Roderick Murchison and the Crown in that year. Subsequently he resigned these appointments, when at the beginning of 1881 he was appointed to succeed Sir Andrew C. Ramsay, as Director-General of the Geological Survey of the United Kingdom, and Director of the Museum of Practical Geology in Jermyn Street.

It is hardly necessary to say that during this period he has engaged in an immense amount of official work. To begin with, he had the direct supervision of the Survey of Scotland almost from its commencement, and has mapped with his own hand many hundreds of square miles of country, besides writing or editing all the published Survey Memoirs descriptive of Scotland. Again, since becoming Director-General in London, he has given special attention to the petrographical department of the service, previously weak, but which has now attained great strength and importance. Professor Geikie was one of the first field-geologists in this country to perceive the importance of microscopic investigation as an adjunct to field-work, and to begin this investigation himself. One direct result of this has been the great enlargement of the petrographical collection of the Museum in Jermyn Street. Upwards of 5000 slides of British rocks have been prepared and are now available for the student in this branch of investigation.

The one-inch Geological Survey maps of England and of Ireland

[1] The portrait accompanying this Notice is most obligingly lent by George A. Ferguson, Esq., Editor of the "Mining Journal," in which periodical it appeared on December 28th, 1889, and from the columns of which this notice has been largely reproduced.—Edit. Geol. Mag.

have been completed during Professor Geikie's tenure of the Director-Generalship. The survey of the superficial deposits over those parts of England and Wales, where they are not previously mapped, is now being carried on. The Survey is at present also gathering up the results of its long labours in the form of descriptive Memoirs of each of the geological formations of the country.

Those who consider the work of the Geological Survey all very easy and plain sailing will probably change their views when we mention that, as a matter of fact, the maps of the Coal-fields and mineral districts have continually to be revised and kept up to date. Constant supervision, too, is necessary on the part of the Director-General in the field-work and office-work connected with the engraving of maps and sections, and the editing of the Memoirs.

Though Dr. Geikie's hands are very fully occupied with his official duties, he has yet found time to engage extensively in exhaustive original research. Amongst the more important investigations carried on by him over and above his official work, may be mentioned his "History of Volcanic Action in Britain." This he has developed in a series of papers wherein the volcanic phenomena of the Old Red Sandstone, Carboniferous, Permian, and Tertiary periods have been illustrated. He has also discussed in numerous papers, and more particularly in his "Scenery and Geology of Scotland," the subjects of denudation and the origin of scenery. His "History of the Glacial Period" gave the first systematic arrangement of the deposits of that period with reference to the probable series of events of which they were the records; while his "History of the Old Red Sandstone of Western Europe" is a laborious investigation, of which the first part is published, and the second part is far advanced. In the prosecution of these researches Dr. Geikie has travelled over much of Europe, and has also studied the broad features of the Geology of the United States and of Canada.

Dr. Geikie has long been intimately associated with the progress of educational work. He has always taken a deep personal interest in promoting the establishment of Natural Science as an instrument in Education. In this connection it may be mentioned that he is the author of primers of physical geography and geology, which have had a very large sale, and have been translated into most European languages, and even into some of those of India. He is also the author of some advanced class-books on the same subjects, of his well-known text-book of geology (now in its second edition), and of geological maps of Scotland and the British Isles.

When appointed in 1871 to the University Chair in Scotland specially devoted to Geology, Dr. Geikie had the whole work of that department to organize. He also prepared a large number of the diagram illustrations used in connection with his lectures with his own hand, and gathered together a valuable class museum.

Dr. Geikie has been largely engaged in literary work, as distinguished from purely scientific dissertation. In this connection it may be said that he has always recognized the importance of cultivating the literary element in scientific essay-writing. He has been the author of many essays and reviews—signed and unsigned—in the leading reviews and journals. Some of these were selected and published in 1882 in a volume entitled "Geological Sketches at Home and Abroad." The main aim of these writings has been to make Science intelligible and interesting to those outside of the circle of actual workers. He has also written a number of biographical notices of his contemporaries published in "Nature," and in the Journals or Proceedings of scientific societies. Two larger biographies—"Memoirs of Edward Forbes" (in conjunction with Dr. George Wilson), and the "Life of Murchison"—the latter giving a sketch of the rise and progress of Palæozoic Geology in Britain, are also from the same prolific pen.

Those who are familiar with Dr. Geikie's style will, we feel sure, agree with us, that he is one of the pleasantest and most attractive writers of our time. His articles have adorned the pages of this Magazine, since its commencement in July, 1864, and have always been most valuable and suggestive, whether they dealt with some special geological phenomenon, such as "the Old Man of Hoy;" "a volcanic bomb in the cliff at Burntisland," or with broad subjects such as subaerial denudation and the physical features and scenery of a country, or the volcanic phenomena of the British Islands.

In these and kindred subjects, Dr. Geikie has shown, not only the pen of the ready writer, but also the pencil of the accomplished artist, and doubtless much of the charm he possesses is due to the combined power to take in and fix rapidly with pencil, as well as graphically to describe, the salient features of the country he is traversing.

It is satisfactory to know that the continuous labour and scientific studies of Dr. Geikie have not passed without recognition. He has been elected into many scientific societies at home and abroad. He entered the Royal Society before reaching the age of 30, a most unusual honour; has been Vice-President, and was recently elected Foreign Secretary of that Society. Within the last few months the Berlin Academy has placed him in its ranks, the Royal Academy of Sciences of Göttingen has elected him to the vacancy caused by the death of the illustrious Studer—the Nestor of Swiss geology, and the Imperial Leopold-Caroline Academy—the oldest scientific Society of Germany—has enrolled him among its members. Dr. Geikie has also been the recipient of the Murchison medal of the Geological Society, and has twice received the MacDougal Brisbane Gold Medal of the Royal Society of Edinburgh. He is an Honorary LL.D. of the Universities of St. Andrew's and Edinburgh.

The Geological Survey of the United Kingdom has every reason to congratulate itself in having for its Director-General not only a practical geologist, but a gentleman so widely known and respected and of such scholarly attainments as Professor Archibald Geikie.

It is an open secret we believe, with most scientific men about London, that Dr. Geikie is the President-designate of the Geological Society, a choice which will be sure to meet with the cordial support and approval of all its Fellows.

II.—Mr. Mellard Reade's Interpretation of the Lower Trias Physiography.

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

If truth is elicited by the conflict of opinion, we ought to arrive at a right conclusion as to the physical history of the English Trias. Unfortunately, however, some of the hypotheses propounded result, as it seems to me, from dwelling too much on certain minor difficulties, or limiting the view to one group of facts, while others not less important are excluded. From these objections Mr. Mellard Reade's interesting communication, printed in the Geol. Mag. for last December, does not appear to me exempt.

Incidentally, however, he clears the ground by his distinct recognition of the fact (often overlooked) that the Bunter and the Keuper were deposited under very different circumstances, and by the statement (grounded on personal observation) that the tripartite division of the Bunter group is not so general or so definite as was asserted by Professor Hull. This removes a difficulty in the hypothesis of a fluviatile origin, which I have always felt to be rather serious.

Restricting his remarks to the Bunter, Mr. Mellard Reade admits that the lake-delta hypothesis is unsatisfactory, and that the choice lies between a fluviatile or a marine origin.

His main objections to the former of these two hypotheses, as I gather from his paper, are the following:—

(1) That he cannot understand the existing distribution of the Bunter on the hypothesis of a fluviatile origin. He adduces some instances of his difficulties. Of these one only seems to me important, the occurrence of Triassic Sandstones in the Vale of Clwyd. Doubtless this is a difficulty, but I find it no more easy to account for these on the hypothesis which he prefers; so that I remain where I was. The patch of Trias, low down in the Eden Valley, does not seem so very anomalous, while I entirely fail to see any improbability in regarding the Pennine Chain as an upland which separated for a time the valleys of two rivers, draining the mountainous region to the north. As for the general tendency of the sandstones to thin off against the hills which bounded the Triassic lowland, that is no more than what we should expect, and agrees with the demeanour of the sub-Alpine drifts at the present day.

(2) That there is no instance on record "of the finding in Triassic Sandstones of anything like a river channel." I should be rather surprised if one had been detected. Rivers discharging sand and gravel on an open lowland, and liable to frequent floods, are constantly changing their courses, and the deposits are so variable that definite channels are not indicated. The same objection would apply to the great masses of post-Pliocene drift which border the Alps, and to the nagelflue and molasse of Switzerland.

(3) That "it is difficult to conceive of a river . . . . bringing down nothing but sand." The sub-Alpine drifts, just named, closely resemble the Bunter pebble-beds, and as regards thickness are not

unworthy of being compared with it. The nagelflue and molasse of Switzerland for a greater thickness than even the Trias of Bootle consist only of pebbles and sand. As I have more than once pointed out, the close resemblance of these deposits to the Lower Trias of the northern half of England indicates a similarity of origin; and though some marine deposits do occur in the Swiss Miocenes, I believe that the freshwater origin of the beds to which I refer is universally admitted.

(4). The disappearance of the northerly "plateau or Alpine range from which the materials of the Trias have been supplied. Why should it have been destroyed, when a lesser orographic feature like the Pennine Chain remains?" Mr. Mellard Reade does not appear to me to be quite consistent throughout his paper in regard to this objection; but letting that pass, I reply that the same kind of objection might be brought forward in regard to the Alps and the Jura. The former have lost by denudation much more than the latter. In fact, for very obvious reasons, of two mountain *massifs* in adjacent regions, the larger is likely to suffer more than the smaller. Further, in asking the question quoted above, Mr. Mellard Reade appears to have overlooked Scotland.

Having thus noticed Mr. Mellard Reade's chief objections to the fluviatile hypothesis, I will briefly mention one or two which occur to me against the marine alternative propounded by him.

(1) Even if we regard it as proved that "the tidal wave produces currents acting through the full depth of the water from the surface to the bottom," is there any evidence that these currents would be capable of sweeping about pebbles 3 or 4 inches in diameter—especially in Central England, where, in order to bring the tidal waves over the north-western region, the estuary should be pretty deep? Indeed, in Staffordshire (where I am writing), where evidence of deposit by powerful currents is very strong, pebbles of over 4 inches diameter are rather common. The Bunter here, *mutatis mutandis*, is identical with the drift bordering the Alps and with the Swiss nagelflue.

(2) Where, we may ask, can we place the communication between the Triassic estuary of North-west England and the open ocean? I venture to think that this serious difficulty has not been met by Mr. Mellard Reade, and that it cannot be brought with equal force against the advocates of a fluviatile origin for the English Bunter. A river can escape from open country through a narrow passage, but for a great tidal wave, competent to sweep to and fro, as he requires it to do, the gate must be wide and the way broad indeed.

(3) Have we any evidence to justify us in ascribing thick beds of conglomerate to marine action? Excepting cases where torrents discharge their contents into rapidly deepening seas—*i.e.* submarine deltas—can any instances be found of marine conglomerates comparable with such a deposit as the Bunter, which at any rate in some parts of England (as here) is a practically unbroken pebble bed at least thirty yards thick?[1] I have never myself read of or met with

[1] Generally, as stated by Prof. Hull (Memoir Triassic and Permian Rocks, p. 108, etc.), and, I fully believe, much more.

any such marine conglomerate, and, so far as I can infer from what I have seen of modern marine deposits, am led to belive that marine conglomerates are rather limited in extent and still more in thickness, under all circumstances but those which I have just mentioned.

I proceed lastly to the facts which Mr. Mellard Reade has overlooked.

(1) No notice is taken of the resemblance presented by the Bunter beds to the Alpine drifts, nagelflue, and molasse, or to parts of the German Trias, deposits for which a marine origin cannot be claimed.

(2) The origin of the Bunter pebbles is treated as if it were still a perfectly open question. "As regards the contained quartzite pebbles, one set of observers contend that they came from the north, another from the south, while a third considers that they have been derived from the destruction of rocks in Mid-England." I venture to think that this is hardly the case, unless (as appears to be the habit of some geologists) we regard a hypothesis which is a mere surmise as of equal value with one which is an induction from facts. Mr. Mellard Reade, moreover, is not even accurate in his statement of this problem. The "quartzites," though the most abundant, are by no means the only larger "materials of the sandstones." Of these it will be enough on the present occasion to mention three:[1]—

(1) Granites, gneissoid rocks and schists—rare and rotten—more resembling Scotch rocks than any other British, but too few and ill-preserved to give any conclusive answer.

(2) Various felstones, not rare. These as a rule cannot be identified with rocks from the Midlands, Wales, the Lake District, or Cornwall, but they exactly correspond with types of felstone which occur abundantly in Scotland.

(3) A peculiar quartz-felspar grit. This rock is identical with the Torridon Sandstone of Scotland, and certainly does not occur above ground in any part of England or Wales.

Next as regards the quartzites. First as to those containing fossils. These pebbles are very rare and different from the ordinary quartzites. They certainly are not unlike those of Budleigh Salterton, but they are also not unlike the fossiliferous 'quartzite' of the Lickey range (in the neighbourhood of which they seem to be rather more common). So that the evidence of these counts for little or nothing in the teeth of that mentioned above. Next in regard to the very compact hard quartzites, to which the majority of the pebbles may be referred (though vein-quartz—which does not help us much—is also abundant). The quartzite of these pebbles is not that of the Stiper Stones, the Wrekin, the Lickey or Hartshill; it is not any quartzite known to me as occurring in England. It is exactly like the quartzite of North-western Scotland, and identical pebbles occur in the newer Palæozoic conglomerates of the south-west of Scotland, the sandy matrix of which is often exactly like that of the Bunter.

I make these positive statements after long and careful study of

[1] Geol. Mag. Dec. II. Vol. X. (1883), p. 199.

the rocks to which they refer, and I challenge those who advocate a Southern or a Midland origin for the pebbles to point to localities within any probable distance where these rocks can be identified *in situ.*

Advocates of the former view must rest their whole case on the supposed identity of a few pebbles with those of the Budleigh Salterton conglomerate, and draw on their imagination for the home of more than 99 per cent. of the materials. Those of the latter must fly for refuge to hypothetical rock-masses concealed from sight beneath newer deposits. They, as it seems to me, will be driven to adopt Mr. Mellard Reade's hypothesis of a marine origin for the Bunter, because, as I have elsewhere pointed out, the rivers in this central region would not be long enough or powerful enough to round the pebbles. To them no doubt Mr. Mellard Reade's hypothesis will be tempting; but others, like myself, will wish to know how it can be accommodated to known facts before we can transfer it from the poetry to the prose of science.

III.—On *Phlyctænius*, a New Genus of Coccosteidæ.[1]

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

(PLATE III.)

In the Geological Magazine for last month (January) I proposed to establish the genus *Phlyctænius* for the peculiar Coccostean from the Lower Devonian beds of Campbelltown in Canada, named by Whiteaves *Coccosteus Acadicus.* In this paper I propose describing that form more in detail, along with an allied, though at the same time very strongly marked species from the Lower Old Red Sandstone of Herefordshire, to which on that occasion I also referred.

Mr. Whiteaves apparently did not recognize the extent of the differences between this species and the true *Coccosteus* of the Scottish Old Red; but this I think he would have done, had he succeeded more thoroughly in deciphering the arrangement of the plates of the cranial buckler. As it is, he seems almost to hesitate as to whether it is specifically distinct from *Coccosteus cuspidatus* of Agassiz. "In some respects," he says, "the Campbelltown *Coccosteus* very closely resembles the *C. cuspidatus* of Agassiz, but in others there are such marked differences between the two forms that it is thought more prudent, for the present, to distinguish the Canadian species by a local name." He notices the similarity in the arrangement of its "superficial" (*i.e.* sensory) grooves, with those of *C. decipiens*, Ag., and finishes by saying: "It would seem, therefore, that *C. Acadicus* may be distinguished from *C. decipiens* by the different shape of the post-dorso-median plate, from *C. cuspidatus* by the different arrangement of the grooves on the outer surface of its cranial shield, and from both by the peculiar sculpture of its bony plates."[2]

[1] Read before the Royal Physical Society of Edinburgh, 15th January, 1890.
[2] Trans. Roy. Soc. Can. vol. vi. sect. iv. 1889, p. 93.

It is, therefore, evident that Mr. Whiteaves was unaware that *C. cuspidatus* is nothing but a mere synonym of *C. decipiens*, and that he also makes no allowance for the fact that Hugh Miller's figure on plate iii. of the "Old Red Sandstone," from which he seems to derive his information as to the characters of this supposed species, is only an imperfect restoration of *C. decipiens* executed at a time when our information in such matters was still rather undeveloped.

The cranial shield of *Phlyctænius Acadicus* (Pl. III. Fig. 1–2) must have been considerably vaulted from side to side, as the specimens, now much flattened, not unfrequently present irregular longitudinal fractures. The form is broadly ovate, truncated behind with prominent *postero-lateral* angles (P.L.). In front of the postero-lateral angle the margin passes obliquely outwards and forwards for a short distance, and then forms another obtuse angle, the *postero-external* (P.E.), succeeded by a shallow notch, in front of which is the antero-external angle (A.E.). Immediately after this the direction of the margin is forwards and slightly inwards to what may be called the post-orbital angle (P.O.), whence proceeding more strongly inwards, it forms a slightly excavated edge, evidently equal to the orbital excavation of the shield of *Coccosteus*, and bounded in front by the ante-orbital angle (A.O.). Between the ante-orbital angles of opposite sides, the margin of the shield is completed in front by a shallow concavity occupied in the perfect state by the "rostral" plate as shown by Mr. Whiteaves.

Leaving the sensory groove system out of consideration for the present, it is first to be noticed that the determination of the constituent plates of the buckler is a matter of extreme difficulty, from the fact that they are apparently all fused or anchylosed together in the manner in which those of the shield of *Pteraspis* are in the adult form supposed to be. Mr. Whiteaves has noticed the frequent arrangement of the tubercles in concentric rows, and this arrangement, much more marked in some shields than in others, along with the lines seen to radiate from the ossific centres in abraded specimens, first led me to suspect that the form and arrangement of the cranial plates differed in some material points from what is given in Mr. Whiteaves' sketch.[1] Close observation by means of a good lens enables one, however, also to observe the original lines of suture, due care being taken not to be deceived by fractures. Though the direction of these sutures is often indicated by depressed lines or slight grooves free from the tubercular ornament, yet the actual suture is not incised, but *slightly raised* like a very fine thread, this being due to the manner in which the original lines of separation between the bones have become entirely filled up by osseous matter.

The results obtained by noting these lines in connection with the concentric arrangement of the rows of tubercles being in all essential respects the same in all the specimens (six) which I have examined, and being furthermore in complete accordance with the information

[1] *Op. cit.* p. 93, woodcut.

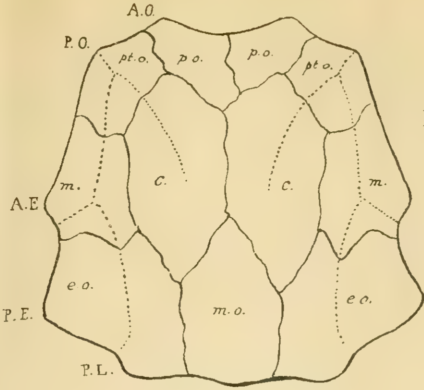


Fig 1.

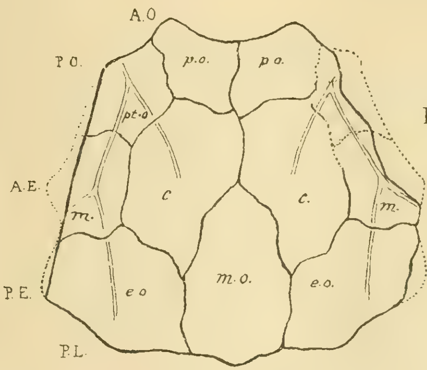


Fig. 2.

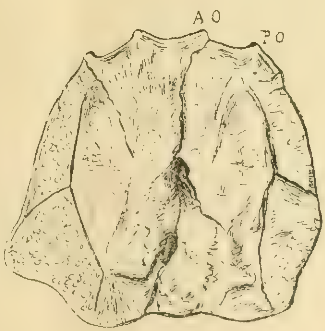


Fig 3.

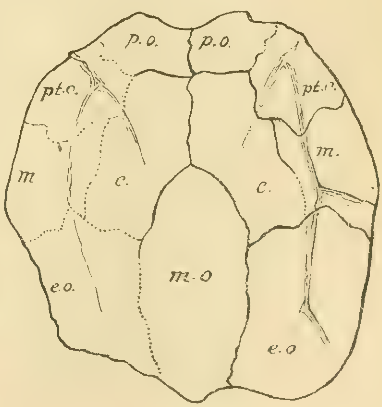


Fig. 4.

PHLYCTÆNIUS

derived from the lines radiating from the ossific centres in a specimen with the surface rubbed off, there can be no doubt that the true form and arrangement of the constituent plates of the shield has been arrived at. The pattern in two shields has been represented in outline in Pl. III. Figs. 1 and 2, and if the reader will compare these figures with that which I have already given of the cranial shield of *Coccosteus*,[1] the fundamental agreement as well as the essential difference between the two will at once be perceived.

The *median occipital* plate (*m.o.*) is more or less five-sided, elongate, truncated behind, pointed in front, where it is wedged in between the hinder thirds of the two centrals. Its ossific centre is near the posterior margin, and is marked by a prominent elevation of the surface. On each side of the median occipital is placed the *external occipital* (*e.o.*), which, although differently shaped from that in *Coccosteus*, forms, as in that genus, the postero-external angle (P.E.) of the shield. In front of these three occipital plates, and occupying a position in the middle of the shield rather nearer the front than the back, are the two *central* plates (*c.*), whose difference of form from those of *Coccosteus* is equally striking, as is the case of the median occipital. They are more or less of an ovate-oblong, approximating to an elongated hexagonal form, articulating in the middle line with each other and round about with all the other plates of the shield except the rostral or anterior ethmoidal. The *marginal* plate (*m.*) is situated on the outer side of the central in front of the lateral occipital, and forms the antero-external angle of the shield (A.E.); in front of it is the post-orbital (*pt.o.*), which forms the post-orbital angle (P.O.), and the posterior part of the orbital margin. The front of the shield is now filled in by the pre-orbital plates (P.O.) which meet in the middle line, form the ante-orbital angle, part of the orbital margin on each side, as well as the anterior median shallow excavation, in which the plate named "rostral" by Whiteaves fits. This rostral plate is not present in any of the specimens in the Edinburgh Museum, but its form and position in the specimen figured by Whiteaves,[2] render it evident that it corresponds with the *anterior ethmoid* in *Coccosteus*.

Some amount of variation is observable in the form of these shields as well as of their component plates. Fig. 2 represents the configuration of a specimen which is proportionally shorter and broader than usual, and in which also the median occipital plate advances further forwards between the centrals, which are more irregular in shape, and have their long axes divergent backwards.

The arrangement of the lateral line system corresponds in the main with that in *Coccosteus*. The lateral groove commences on each side in the external occipital plate near the postero-lateral angle of the shield. Running forwards and slightly outwards, it passes on to the marginal plate, where it gives off a branch backwards and outwards to the edge of the shield just behind the postero-external angle. The main groove then turns forwards and slightly inwards at an obtuse angle, and on passing on to the post-orbital turns on the

[1] Geol. Mag. Dec. III. Vol. VI. Pl. I. Fig. 2.
[2] *Op. cit.* pl. ix. fig. 1.

middle of that bone acutely backwards and inwards, ending on or near the centre of ossification of the central plate. Just at the point where the backward turn commences, a short branch is given off which ends in the post-orbital angle or prominence.

Mr. Whiteaves represents the main groove as again continued forwards at an acute angle so as to end at the front of the shield near the ante-orbital prominence. Judging from analogy with *Coccosteus*, one might expect it to do so, but this continuation is not exhibited in any of the specimens which I have examined.

Associated in the same deposit with the cranial shields are found various other isolated plates, which from their sculpture probably belong to the same fish. Of these the only one which seems to be clearly identifiable is the median dorsal plate (Whiteaves, *op. cit.* pl. ix. fig. 2). The plate which he has figured as "left pre-ventrolateral" (*ib.* fig. 3), if it is so, must belong to the right side of the body, but his "ventro-median (?)" cannot be referable to a median position as it is unsymmetrical. The Edinburgh Museum possesses a number of such detached plates of different forms, but I am certainly not prepared to speculate at present as to their position on the body cuirass. One thing is at least evident, namely, that if those plates really belong to *Phlyctænius*, their difference of form from those of *Coccosteus* certainly gives additional emphasis to the distinctness of the genus. No trace of the maxillæ or mandibles of *Ph. Acadicus* has, so far as I am aware, been yet discovered.

Phlyctænius Anglicus, sp. nov.

A good many years ago a small lot of fossils from Herefordshire was purchased from a London dealer for the Edinburgh Museum, and among them I found a small cranial shield, which, being obviously referable neither to *Cephalaspis*, nor to *Pteraspis*, nor to *Scaphaspis*, was rather puzzling in its appearance. Being, however, at the time specially engaged with other subjects, this shield, from Cradley, lay rather neglected, till one day I bethought me of it when examining our collection of fish remains from the Devonian rocks of Canada, and I was then greatly interested to find that the English fossil was in reality a Coccostean, and a Coccostean not of the type of *Coccosteus decipiens*, but of *Phlyctænius Acadicus*. This is of special geological interest, seeing that both in England and Canada this type is associated in the same beds with *Cephalaspis*, whereas not a trace of any Cephalaspidean has ever occurred in those northern Old Red Sandstone deposits (Orkney, Caithness, and Moray Frith) in which the typical *Coccosteus* is abundant. Nor does *Coccosteus* occur in Forfarshire, where *Cephalaspis* is characteristic.

At the time I made this discovery no one seemed to know of the existence of a Coccostean in the Cradley beds, though indeed a piece of the shield of this very species is figured by Lankester in his Monograph of the Cephalaspidæ (pl. viii. fig. 4) as a "fragment of doubtful character" in connection with *Zenaspis Salweyi*.[1] How-

[1] Mr. Wm. Davies seems to have believed in the occurrence of "Placodermi" in the Herefordshire beds, as he labelled some fragments in the British Museum "*Pterichthys*." They do not, however, belong to that genus.

ever, a short time after communicating with Mr. Smith Woodward on the subject, I received a letter from that gentleman informing me that he had since discovered, in the stores of the British Museum, quite a number of specimens apparently identical with that to which I had referred. He also kindly forwarded to me a plaster cast of one of them, as well as outlines in pencil of two others.

In Pl. III. Fig. 3, I have given a sketch of the specimen in the Edinburgh Museum. It measures $1\frac{3}{4}$ inches in length, and in general form resembles the cranial shield of *P. Acadicus*, except that at the back it is more produced outwards, as in *Coccosteus*, the postero- and antero-external angles being confluent into one of considerably greater prominence. In front we have the same more anterior direction of the orbital excavations, bounded by the post-orbital and ante-orbital prominences, and between the latter (of each side) we have a similar gentle concavity for the rostral or ethmoidal plate.

It is the internal or concave aspect of the shield which is here exhibited, and it is extremely difficult to recognize any sutures except that separating off the median occipital, which shows distinctly enough that this plate had the same elongated pointed form as in the Canadian species. The bone being considerably splintered away, especially on the right side, some of the external markings are seen in impression, showing that the surface was sculptured with tubercles of a comparatively large size. The course of the lateral-line groove may be distinctly enough seen, its disposition being quite similar to that in *P. Acadicus*,—the main groove, starting in the external occipital, passing obliquely forwards and inwards to the ossific centre of the plate, then proceeding forwards and slightly outwards for a little distance, and sending a branch obliquely backwards and outwards to the external angle of the shield, after which it proceeds forwards and slightly inwards to behind the postero-orbital angle. There, a ridge on the inner surface of the shield indicates that it turns at an acute angle backwards and inwards to the middle of the central plate in a manner quite similar to that already seen in *P. Acadicus*.

Figure 4 is a diagram-sketch of the plaster cast sent me by Mr. Smith Woodward, taken from a specimen which clearly belongs to the same species, and which shows many points with greater clearness than that belonging to the Edinburgh Museum, the outer surface being here displayed. It measures two inches in length by two in breadth, but has a piece broken off at the posterior part of the left side, while on the right it looks as if the prominent external angle were covered by the matrix. The surface is covered by a coarse pustular tuberculation, omitted in the figure, showing at places a little, but not much, of the concentric arrangement; the course of the lateral-line grooves is clearly discernible, while the form and arrangement of the constituent bones may be pretty fairly made out, both by actual indications of sutures as well as by radiating lines where the surface has been abraded. It is clear also, from both specimens, that these bones were quite fused or anchylosed together, and in the cast now under description the sutures are sometimes indicated by delicate raised lines as in *Ph. Acadicus.* I have indicated in the sketch the course of the divisions between the plates, naturally in a somewhat exaggerated manner, as the lines themselves are only visible by a lens and often cannot be followed at all. But from what is seen it is quite clear that the plates were quite similar in general form and arrangement to those in *P. Acadicus*, and especially to those in the specimen represented in Fig. 2, the median occipital extending far fowards and the centrals being rather truncated in front.

One of the pencil outlines sent to me by Mr. Smith Woodward shows apparently the rostral or ethmoidal plate in situ, thus completing the generic resemblance between the Canadian and English species.

We may therefore sum up the results of the preceding investigations as follows:—

Genus *Phlyctænius*, Traquair. Cranial shield more ovate than in *Coccosteus*: constituent plates anchylosed, except the ethmoidal; median occipital elongated, pointed in front and wedged in between the posterior ends of the oblong or ovate central plates; orbital excavation looking more anteriorly than in *Coccosteus*; course of main lateral-line groove nearly straight from the external occipital to the postorbital, where it is very acutely bent backwards. Plates of body-cuirass imperfectly known.

1. *P. Acadicus*, Whiteaves sp. External angle of cranial shield divided by a shallow notch into two, the postero- and antero-external angles; surface ornamented by fine tubercles, in most specimens showing a concentric arrangement parallel to the margin of the constituent plates. Lower Devonian, Canada.

2. *P. Anglicus*, Traquair. Postero- and antero-external angles confluent, surface covered by a coarse pustulation. Cornstones, Herefordshire.

In conclusion my most hearty thanks are due to Mr. Smith Woodward for the information he has afforded me regarding the Herefordshire specimens in the British Museum, and to Dr. Woodward, F.R.S., for permission to make use of the plaster cast taken from one of these specimens.

EXPLANATION OF PLATE III.

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

P.L. postero-lateral angle. P.E. postero-external angle. A.E. antero-external angle. P.O. postorbital angle. A.O. ante-orbital angle. *m.o.* median occipital. *e.o.* external occipital. *c.* central. *m.* marginal. *pt.o.* post-orbital. *p.o.* preorbital. *e.* ethmoidal.

Fig. 1.—Restored outline showing the arrangement of the plates and lateral-line grooves in the cranial shield of *Ph. Acadicus*, Whiteaves sp.

Fig. 2.—The same in another specimen, lateral margins of the shield restored in dotted outline.

Fig. 3.—Sketch of a specimen of the cranial shield of *Ph. Anglicus*, Traquair, from a specimen in the Edinburgh Museum.

Fig. 4.—Sketch of a plaster cast of another specimen, contained in the British Museum, the surface ornament being omitted.

IV.—On a New Locality for the Arctic Fauna of the "Basement" Boulder Clay in Yorkshire.[1]

By G. W. Lamplugh.

Introduction.

During the course of a systematic investigation of the drifts of Flamborough Head, I have somewhat unexpectedly come across a fragment of marine Arctic beds enclosed in Boulder-clay, similar to those which form the well-known fossiliferous deposits of Bridlington and Dimlington;[2] and as this occurs under very different conditions from those already described, it adds materially to our knowledge of the beds, and illustrates more clearly their origin.

The newly-discovered bed lies in the face of the cliff on the east side of a shallow recess in the southern coast-line of Flamborough Head, known as "South Sea Landing." This place is within half a mile of the village of Flamborough, and is about four miles north-east of Bridlington, the latter being the nearest previously known locality for the beds.

The chalk on both sides of this recess forms vertical cliffs below the drifts, varying from 60 to 80 or more feet in height; but here, having been excavated in pre-Glacial or early Glacial times, it sinks suddenly to the sea-level.

The hollow thus formed has a breadth of about 300 yards, and is bounded on the west side by an abrupt cliff of chalk. On the east side the surface of the chalk shows a more gradual incline, but I believe that this is a deceptive appearance due to the line of section running at a very low angle to the scarp, and cutting it very obliquely, since a close examination of the drifts shows that they are banked against a very steep slope.

On the west side, the old valley-floor, standing two or three feet about high-water mark, extends from the cliff of chalk for 60 or 70 yards in a very gently sloping terrace which is strongly suggestive of a tidal flat, but toward the eastern boundary of the hollow the chalk floor sinks below beach-level.

This old hollow has been entirely filled in by drift deposits in Glacial times, but since that time a puny stream of surface water, which drains to the beach, has cut a narrow V-shaped ravine through the midst of the drifts. The sea has also eaten back further into the coast-line than where the chalk stands higher, and has thus formed the little recess of the South Sea Landing in whose nearly vertical cliffs, from 100 to 125 feet in height, most excellent sections of this curious infilling material are revealed.[3]

[1] Read at the Brit. Assoc. Newcastle, before Section C (Geology), Sept. 1889.

[2] For description of the Bridlington and Dimlington beds see Clement Reid's Survey Memoir on Holderness, pp. 8–26, and my papers in Geol. Mag. Dec. II. Vol. VIII. pp. 535–546, 1881; and Q.J.G.S. vol. xl. p. 312, 1884.

[3] These sections have already attracted some attention from geologists, and are mentioned by J. Phillips, Geol. of Yorksh. pt. i. 3rd ed. p. 91; T. Mellard Reade, A Traverse of the Yorkshire Drift, Proc. Liverpool Geol. Soc. 1882–3, p. 11; Wood and Rome, Q.J.G.S. vol. xxiv. p. 180; and J. R. Dakyns, Proc. Yorks. Geol. and Polyt. Soc. vol. vii. p. 249 (1880).

I do not propose in this paper to enter into the intricacies of this section further than is necessary to explain the relations of the shelly sand, leaving for some future occasion the discussion of the drifts as a whole. The accompanying section (Fig. 1), as seen in the cliff on the east side of the recess, will give some idea of the character and complexity of these deposits; and a few words of description will also be necessary. Between this and the opposite side of the hollow there are, however, considerable differences, the west side showing a much greater development of Boulder-clay, and a corresponding diminution in the thickness of the stratified beds which there lie tolerably evenly, and chiefly below the mass of the clay. (See Fig. 1.)

The Section.

The chalk-rubble (1) which rests on the chalk in this section differs only slightly from that which forms the base of the drifts nearly everywhere on the headland, but is of unusual thickness, and is distinguished by the presence of well-marked bedding-planes. Its thickness in the middle of the valley may, however, be more apparent than real, as I think it very probable, as suggested above, that we may be looking towards a hidden wall, or very steep slope, of the solid rock against which this rubble is banked.

The curving and steeply-sloping planes of stratification of this deposit look like cross-bedding, but are not of the normal character. Instead of sloping parallel to one another as in ordinary cross-bedding, most of the bedding planes converge downward, in sweeping curves, upon one horizon. This appearance, again, may possibly be due to the obliquity of the section.

The manner in which, on the west side of our section, the upper part of this rubble ends up against Boulder-clay, and on the east passes into it, shows that the rubble must in some degree have been formed contemporaneously with the clay. The occasional presence in it, also, of erratic blocks of large size, and the broken character of the chalk surface below it, point to a glacial origin; but its bedding and its connection with thick masses of sand and silt (1*b*) between *B* and *A*, show that it can scarcely be considered as true bottom-moraine.

I may briefly state that I think it has probably accumulated in the hollow between the glacier and the old cliff before the advancing ice had yet over-ridden the chalk; but to show clearly how this may have taken place would need a longer disquisition on the general character of the drifts than I propose now to make.

The lowest Boulder-clay (2) is seen as a tolerably solid mass on the south-east side of our section (Fig. 1), and it is even better developed on the headland immediately to the eastward. But if it be traced in either direction, it loses its massive character and shows a disposition to include irregular and contorted threads, veins or patches of stratified beds (2*a*). These stratified beds consist of sand, silt, gravel, clay, or even occasionally, though not in the immediate vicinity of this section, of transported Secondaries. These inclusions are of all shapes and sizes, and it is often difficult to define their boundaries in the clay. Though the Boulder-clay itself generally contains many shell-fragments, the inclusions are as a rule unfossiliferous; it is an exception to this rule (2*b*) which it is the proper object of this paper to describe.

To finish my description of the section, the above-mentioned Boulder-clay generally rests directly on the chalk-rubble, as shown on the right in my section; but towards the centre of the South Sea Landing its base rises higher so as to admit the intervention of thick sandy and silty beds (1*b*) that seem at first to be interbedded with the rubble. The Boulder-clay thins out over these, till it finally disappears, and the stratified beds above and below it then come together for a short space as shown at C.

This thinning out evidently takes place in a north-easterly direction, as is shown by the reappearance of the clay after we turn the angle of the bay at *C*.

Above the shelly Boulder-clay lies a thoroughly-washed gravel (3), with regular bedding well brought out by sandy seams. It differs from the lower stratified beds in containing a very much larger proportion of foreign pebbles, some of them of large size; and indeed in many places it includes scarcely any chalk. Its thickness varies considerably, changing even within the limits of my section from 2 to 12 feet, while half a mile away on the opposite side of the Landing, at Beacon Hill, the cliff section cuts across a mound of sand and gravel about 80 feet thick, which I believe to be an exaggerated local development of this same gravel.

Shell-fragments, small and well-rounded, may be detected in it, but I look upon these as being as much "pebbles" as are the fragments of Liassic and other fossils which it also contains. It is evidently a re-assortment of the Boulder-clay material, either derived from the denudation of the clay, or, more directly, from the laving of the ice which carried and formed that bed.

Capping the section we have a thick mass of brownish Boulder-clay (4), much more homogeneous in character than the lower bed. The thickness of this clay is about 25 feet, but in one or two places a band of pebbles (4*a*) occurs 6 or 7 feet from the top of the cliff, which may indicate a line of division.

This upper clay is perhaps on the whole the most constant factor of the Glacial series of Flamborough Head, though it thins away and disappears in one or two places, as over the flanks of the above-mentioned great sand and gravel-mound at Beacon Hill.

The Shell-bed.

I will now revert to the mode of occurrence of the shell-bed. The chief portion of the fossiliferous deposit takes the form of an irregular lenticular seam of greenish-yellow sand, about 24 feet long and at its thickest part not more than four inches thick. This bed is curiously crumpled and twisted among the surrounding clay, and at either extremity it is drawn out into a mere contorted thread.

The accompaning figure (Fig. 2), in which a part of the section shown in Fig. 1 is enlarged, is intended to bring out these features.

As shown above, other irregular beady streaks of similar sand occur both above and below the main seam, but these are quite of minor consequence, and, when traced, are found to fall into the larger bed.

Surrounding these sandy seams there is a variable thickness, from 15 to 40 inches, of tenacious blue or greyish clay which differs in many respects from the Boulder-clay which borders it. It carries very few pebbles, and, though full of shearing-planes, shows distinct traces of stratification and lamination, and is altogether clearly an aqueous deposit.

Similar clays are also found at Bridlington and Dimlington associated with the sandy shell-beds, and sometimes themselves bear shells. These I regard as glacial muds formed on the same sea-bottom as the shelly sand, and probably in sequence with it, which have been removed and carried forward along with the sand. In former cases I thought the clay had been deposited before the sand,[1] but in this instance the beds have been rolled over and folded upon themselves, and it is impossible to make out their original arrangement.

Besides shells, the sand contains a few small, well-worn pebbles, not generally larger than beans, and these are not chalk or flint, but usually of a dark, close-grained igneous rock, or otherwise of yellow quartz, though many other varieties are present. The sand itself is chiefly made up of rather coarse quartz-grains, and altogether the bed is not of such a nature as would be likely to form on a floor of chalk.

A neighbouring streak, containing many crushed shells, consists almost altogether of these small dark pebbles, with but little sand.

The state of preservation of the shells deserves especial attention, as there is in this case such unmistakable proof that the bed has been transported bodily, and has undergone a considerable amount of shearing during the process.

In the minor streaks the shells are always reduced to fragments, and in the main seam also the majority are broken, though not so shattered.

In this seam, however, a small proportion occur in perfect condition, the bivalves even in some cases having their valves united. I obtained many specimens of *Astarte compressa*, which is the commonest fossil of the bed, in this condition, and also of *Astarte borealis*, some fine examples of the latter measuring over an inch across the valves.

When the shells are broken, the fragments occasionally still lie close together, though oftener they have been trailed apart during the shearing of the bed. As showing the effect of this shearing, it is most interesting to find instances in which the two valves of an *Astarte* have been displaced or separated without fracture, thus clearly proving a differential motion. These specimens also illustrate a curious feature noticeable in the Boulder-clay, wherein detached valves of various species may be found retaining a small pinch of sand under

[1] Q.J.G.S. vol. xl. p. 317.

the umbo, even when the Boulder-clay shows no other sign of the demolition of sand-beds. Until now I have found it difficult to understand the preservation of sand in such a position, but this difficulty has been cleared away by specimens which I have collected from the edges of the deposit under consideration. These show how one valve lying near the borders of a sandy seam may be driven forward into the clay by a lateral squeeze or push, carrying with it the sand which lay sheltered under its edges, while the other valve may remain imbedded in the sand. And when once a valve is thus incorporated with the clay, the sand under the umbo is effectively plugged in by the clay, and it is easy to understand how it may remain there if the shell remain intact, notwithstanding any further motion the mass of the clay may undergo.

Thus, I collected unbroken specimens of *Astarte compressa* often where the sand seam was so thin that both valves were nearly touching the clay, in which, though the valves remained in contact, they were twisted about so that the umbos did not coincide; others in which one valve had been pushed forward so as to touch the other at one point only; and others again in which the valves were quite separated; and in more than one case one valve with its contained sand had been so far displaced as to lie in clay.

It is somewhat curious to note that in the main seam the shells had suffered most where the sand was thickest, and that unbroken specimens were more common toward the extremities, where the seam was tapering out, than in the centre.

The following is a list of the species I have obtained from the bed. All these species occur also both at Bridlington and at Dimlington. The list is small as compared with the list of over 100 species from the former place; but this we might expect from the very limited nature of the seam, which can only represent one small portion of the sea-bottom, whereas at Bridlington not only were the patches of larger size, but they also showed great diversity and had evidently been brought together from different areas.

List of Species found at South Sea Landing.

c *Pecten islandicus*, Müller.
Mytilus modiolus ? L.
Leda (*limatula*, Say ?).
Cardium groenlandicum, Ch.
c *Cyprina islandica*, L.
c *Astarte borealis*, Ch., and vars.
c ——— *compressa*, Mont.
——— ————, var. *striata*.
——— *sulcata*, Da Costa.
Mya truncata, L.
Mya truncata, var. *uddevallensis*.
Saxicava norvegica, Spengler.
——— *rugosa*, L.
c *Dentalium striolatum*, Stimpson.
Turritella erosa, Couth.
Natica islandica, Gm.
Fusus despectus, L.
Admete viridula, Fabr.
Balanus (*crenatus* ?) Brug.

c indicates that the shell is plentiful.

Almost everywhere on the headland the Basement Boulder-clay contains a plentiful sprinkling of broken shells, which, along with the sea-worn and *Pholas*-bored pebbles, are doubtless derived from the complete destruction of beds such as these. But it is worthy of note that, as in former instances, while in the clay *Tellina*

Balthica is by far the commonest shell, it is not found in the sand-seam; and on the other hand that, though *Astarte compressa* is so abundant in the sand, it is rare in the surrounding clay.

It appears as though the shallow-water and shore-line beds in which *Tellina* abounded have been more thoroughly obliterated than the deeper-water deposits where *Astarte* and *Dentalium* lived.

In this new locality, though the shell-bed itself is so limited in extent, it possesses one great advantage over the previously-known exposures, which causes the section to possess a peculiar interest; for whereas up to this time the shelly patches have always been found either at the foot of the cliff or on the beach, so that nothing could be learnt as to what lay below them, at South Sea Landing the fossiliferous bed is exhibited in section, and we see the whole of the drift series resting on chalk.

It has been thought possible in the previous instances that beds similar to the inclusions might occur undisturbed lower in the section; but in the new locality we see plainly that the stratified sand, silt, and gravel which underlie the Boulder-clay containing the shell-bed have nothing in common with the inclusions, and are quite unfossiliferous. Neither in the stratified bed which overlies the shell-bearing Boulder-clay is there any sign of contemporaneous fauna, the few worn shell-fragments to be found therein being evidently mere pebbles.

We have thus now, not only clear proof that the shells did not live where they now occur—a supposition which every feature of the section makes it unnecessary to discuss,—but also evidence to show that they are truly transported boulders, and have not been derived from the destruction of beds which existed in the immediate locality, for we find that no shell-bearing beds occur anywhere in place in these sections.

Origin of the Shell-bed.

That the formation of the Boulder-clay containing this shelly sand has been the work of land-ice which filled the basin of the North Sea and encroached upon the land, I have little doubt; but as to the exact mode in which the sand has been transported I confess I can form no clear conception.

The work of the ice in this part of the country seems chiefly to have been in the spreading out of successive pavements of clays and gravels, and it is only here and there that we find proof of its erosive influence. Consequently while I can understand well enough how a glacier advancing over a sea-bottom on which lay deposits of sand and clay might churn these up and mix them with its own debris in passing over them, thus manufacturing such a mass as the Basement Clay, I do not see how the sea-bottom could be dragged *under the ice* for long distances and raised to higher levels. Indeed, I think that all the evidence goes to show that the shelly masses when transported were actually *embedded in the ice*, and that their journeying has been exactly analogous to that of the solid boulders. But how they came to be lifted upwards so as to attain to this position in the ice I cannot understand. I am sometimes inclined to speculate on the effect of "anchor-ice" forming in water of some depth at or under the edge of an advancing or gradually thickening ice-sheet, which, buoying up portions of the sea-bottom, might become affixed to the glacier as part of its mass and be driven forward with it; but this is, of course, mere guesswork.

But however carried, the curving lines and scattered shells of the included bed show that it has, either during or after its transportation, been rolled out and sheared by the passage of a heavy mass above it, and we can see that had the movement gone on a little longer, the clays and sands which now appear as streaks and patches would have become completely merged into the mass of the Boulder-clay. In fact, at this spot we study the Basement Boulder-clay in a state of arrested development.

It has frequently been noticed that the shells found in the drift deposits of the Western side of England indicate a warmer climate than those found on the Eastern side, and this has sometimes been quoted as evidence that the beds were not synchronous. But if it be taken as proved that at a certain period the Scandinavian ice-sheet coalesced with that of Scotland, then during that period whatever portion of the North Sea remained to the south of the ice must have been practically severed from the warm Atlantic and converted into an inclosed basin almost surrounded by ice-cliffs, wherein we may well imagine an Arctic fauna could establish itself. But during the same period the currents of the great Atlantic would preserve the more temperate fauna comparatively unaltered on our western shores.

This fact of the destruction of a glacial sea-bottom, and the incorporation of its material in the mass of the Boulder-clay, must not be lost sight of, as Clement Reid points out,[1] in studying the distribution of boulders in our Eastern Counties drifts. Under such circumstances the mere presence of fragments of Scotch, Scandinavian, or Baltic rocks in the clay cannot alone prove, as it seems sometimes to be taken as doing, that an actual flow of the ice has passed from those localities to the spot where the boulder is found.

During the encroachment of the glaciers there must have been a long period when the North Sea was crowded with ice-bergs and floe-ice, and these, floating hither and thither at the mercy of wind and tide, would scatter their blocks indiscriminately, and bring about much "intercrossing of erratics."

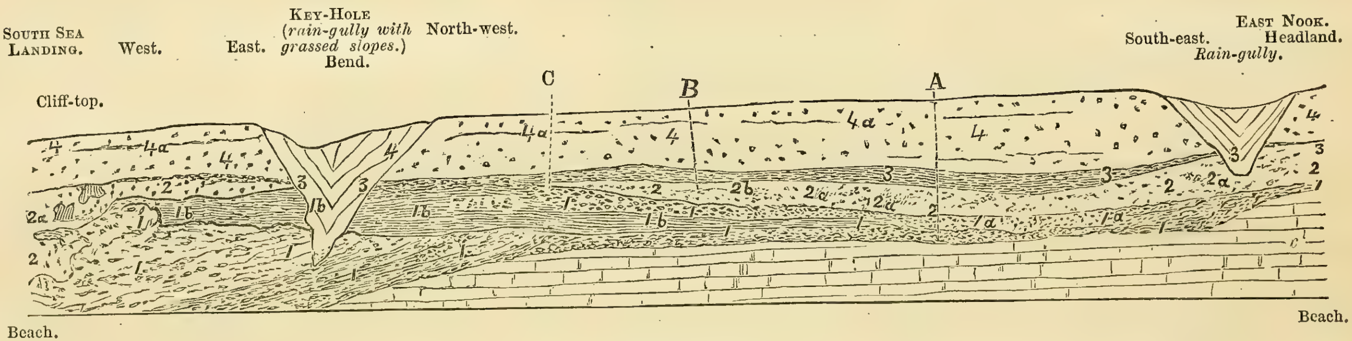
Thus at any one spot there might be brought together boulders from all parts of the catchment-area of the basin, and these, when the land-ice reached the spot, might be incorporated in the resulting Boulder-clay just as the shelly sands have been. Indeed the presence of innumerable *Saxicava*- and *Cliona*-bored stones and well-rounded beach-pebbles in the clay proves that many of its boulders have thus been derived.

Another point of interest in connection with this section is that

[1] Survey Memoirs: "Cromer," p. 90, and "Holderness," p. 43.

FIG. 1.—SECTION OF THE CLIFF ON THE EAST SIDE OF SOUTH SEA LANDING, FLAMBOROUGH HEAD.

Scale: 120 feet to 1 inch. Length of section: 290 yards. Average height: 125 feet.



EXPLANATION.

4. Brownish Boulder-clay: a band of pebbles, 4*a*, in places about 7 feet from the top.

3. Washed gravel, with thin sand-seams: well-bedded: pebbles chiefly erratics.

2. "Basement" Boulder-clay, with many included patches of sand, gravel, and silt, 2*a*: at B one of these 2*b* contains shells.

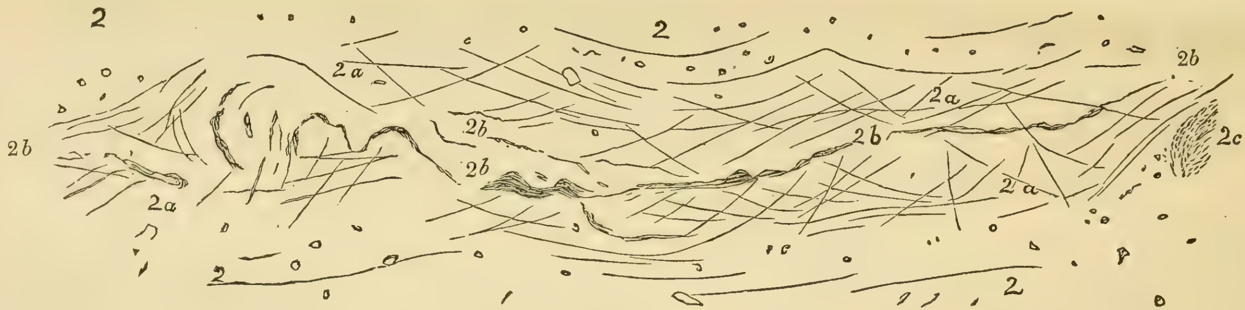
1*b*. Sand and silt, overlying and in places interbedded with 1.

1. Rubble of angular and subangular chalk-blocks and gravel, with an occasional erratic: passes partly into chalky Boulder-clay, 1*a*.

x. White chalk, without flints: surface much shaken.

FIG. 2.—ENLARGED SECTION OF THE SHELLY SAND AND SURROUNDING CLAY AT B. IN FIG. 1.

Scale: 4 feet to 1 inch.



EXPLANATION.

2. "Basement" Boulder-clay.

2*a*. Pure compact blue and brown clay of aqueous origin: bedding contorted and nearly obliterated, but the mass is cut up by shearing-planes.

2*b*. Irregular seam, and scattered streaks, of greenish-yellow sand with many marine shells.

2*c*. Patch of pale yellow sand, different from 2*b*, without trace of fossils.

it places beyond all doubt what has been until recently[1] an undecided point, the extension of the Basement Clay over Flamborough Head, and consequently over a large area in the region to the northward, and this will materially affect the classification of the drifts of that part of the coast.

In conclusion, it may perhaps be as well to mention that the place where the shell-bed is to be seen is on a steep slope at the top of a chalk cliff, and, though not really dangerous, is certainly not easy of access, and is formidable-looking to any one unaccustomed to clamber about on high places.

V.—On the Climate of the Loess Period in Central Europe and the Cause which Produced it.

By T. F. Jamieson, Ellon, Aberdeenshire.

UNDER the name of "*Loess*" there has been confounded two kinds of deposit which are due to entirely distinct and different causes. One is the fine-grained sediment left by the muddy water of flooded rivers and streams of all sorts; the other is the powdery dust and sand carried by wind, which in dry regions often produces large accumulations of this nature.

It would be well, I think, if the term "*Loess*" were restricted to this latter deposit, or at all events it would be desirable to have a distinct geological term for each kind. There is no doubt, however, that both agencies have frequently contributed to the formation of these so-called Loess-beds, for in one and the same locality blown dust and watery sediment may be lodged alternately, according to the varying phases of the weather.

Many years ago Morlot in Switzerland, and Collomb in France, pointed out that much of the material to which the term "*Loess*" is applied in these countries had probably been derived from the muddy streams which flowed from the old glaciers of the Ice-time, for water issuing from the bottom of glaciers is generally loaded with a fine floury sediment produced by the grinding action of the ice upon the mineral matter beneath it. This explanation accordingly met with very general approval; but when the German geologist Richthofen extended his travels into Northern China and Mongolia, he there found Loess-beds developed on a gigantic scale, and displayed in such a way as to announce in no obscure language the cause which produced them. In these arid regions the desert winds play an important part in the economy of nature, and carry along great clouds of sand and dust which they drop in more sheltered places where their force begins to slacken. In moist climates the fine earthy powder which is continually forming on the surface of the country by the action of the weather is washed off by the rain and rivers; but in rainless districts it is left to the mercy of the winds, which in the course of long ages gather deep beds of it, and these so closely resemble in character and in organic contents

[1] See Report on Buried Cliff at Sewerby, British Association for 1888 (p. 335).

the Loess of Central Europe that most German geologists seem now to believe that both have been produced by very similar causes.

A curious and interesting confirmation of this opinion has in recent years been got by Dr. Nehring,[1] of Berlin, who has discovered in the Loess deposits of Brunswick and other parts of Germany numerous remains of animals, such as the *Alactaga jaculus*, *Spermophilus rufescens*, *Arctomys bobac*, and various species of *Arvicola*, which are found only in very dry open districts like the Steppes of Eastern Russia and Siberia. He accordingly maintains that at the time these animals flourished in the heart of Germany, Central Europe must have had a very dry continental climate. In order to account for this dry steppe-like climate, Nehring supposes that Europe had then extended much further into the Atlantic towards the west and north-west, and that there was perhaps even a land communication between it and North America.

My object in this paper is to show that there is no necessity for invoking this great extension of our continent to the westward, and that the dry climate which Nehring wants would arise as a necessary consequence from the train of events which we know took place during the Glacial period. It is now admitted on all hands that when the great Scandinavian Glacier attained its maximum development, it came down like a flood into the plains of Poland and Germany, and advanced onwards until it reached the frontiers of Bohemia.

To the eastward it seems to have stretched over the plains of Russia as far at least as Moscow, if not for some distance beyond it. Such being the case, we need not be surprised to find that it approached the shores of Britain in its westward march, and coalesced with the ice which was streaming out in all directions from Scotland and the North of England. In fact, if the British ice had not been in great force, it is evident the Scandinavian glacier (judging from its range to the south and east) must have invaded this country to a considerable extent, as indeed it seems actually to have done along part of the English coast. We know from the investigations of Messrs. Horne and Peach that its influence was felt at the Orkney and Shetland Islands, while our own Geological Survey, together with Otto Torell and the late Mr. Carvill Lewis, have found traces of its presence from Norfolk to Holderness. Well, what does this imply? The Baltic and the German Ocean must have been for the time abolished, and the western border of the ice would have been thrust out into the Atlantic somewhere probably about the 100-fathom line or beyond it, running along between Shetland and the Faroe Islands, and lying out beyond the Hebrides and the Irish shore. The sea also between Norway and Iceland would probably have been frozen over during most of the year. Here then we have conditions which amply suffice to have produced a dry continental climate in Central Europe; for we have a thousand miles of ice lying between it and the open water of the ocean all round to the north and north-west.

[1] Geol. Mag. Feb. 1883; also, Neues Jahrbuch für Mineralogie, etc., 1889, p. 66.

To the east there was nothing but land, and to the south the great snowy Chain of the Alps shut off in a great measure the influence of the Mediterranean and the Adriatic. Unless it was from the neighbourhood of the Bay of Biscay, it is difficult to see where the rain could come from; and even that is a long way off, with hilly ground between. Now this state of matters would have been more effective than a mere extension of the land such as Dr. Nehring has contemplated, for such a mass of ice lying along the north-western border of Europe would act as a powerful condenser upon the moist winds coming in off the Atlantic. Precipitation would therefore take place before the clouds could reach the heart of Germany, and the climate there would be one of extreme dryness. France would not be so much affected; but in travelling from France eastward through Germany to Austria the dryness would steadily increase. Accordingly it is found that the extent of the ancient glaciers in these regions rapidly diminished as they are traced to the eastward. In the Carpathian Mountains they were small and confined to the higher parts of the chain, as we know from the investigations of Partsch (*Die Gletscher der Vorzeit in den Karpathen*).

The Loess on the other hand seems to augment in volume eastward from the coast of France, as we should expect on the theory I am advocating. It thickens in the Valley of the Rhine, and is largely developed in the basin of the Danube, while over Southern Russia it extends in a continuous mantle.

In England there is a slight suspicion of it in the south-eastern counties. Much of the brick-earth in that quarter probably consists of wind-driven dust mixed at times with sediment proceeding from the muddy water of melting snow and outbursts of rain. There is even some trace of Nehring's Steppe-fauna at Salisbury, where Dr. Blackmore[1] got remains of Lemmings, *Spermophilus*, etc., along with the bones and egg of the Wild Goose.

When geologists attempted to account for these Loess-beds solely by the action of water, they found themselves involved in considerable perplexity, as may be seen in Sir Charles Lyell's chapter on the subject in his "Antiquity of Man," and also in the papers of the late Thomas Belt; for this deposit often occurs on the sides and tops of hills to which flooded streams could hardly be supposed ever to reach. Moreover, the characteristic shells which are everywhere found in the Loess are not aquatic or fluviatile species, but belong to kinds which have a northern range over cold dry regions.

Penck, in his *Landerkunde von Europa*, points out in regard to the Loess that its central point of development lies quite outside the Glacier region, and that it appears in places which were inaccessible both to the ice itself and the melting water proceeding from it. He looks upon it as "*an interglacial steppe formation*."

If the Loess were a deposit from the muddy water that issued from beneath the old glaciers, how comes it that we do not find it in Scandinavia and Scotland where glaciers abounded? Neither do we hear of it in Eastern Canada or New England. It appears,

[1] Journ. Geol. Soc. vol. xx. p. 192, 1864.

however, in some of the dry regions in the interior of North America, just where we might expect to find it on Richthofen's theory.

I maintain, therefore, that upon meteorological principles a very dry climate in Central Europe was the necessary and inevitable result of the great spread of glacier-ice over Scandinavia and the British Isles, inasmuch as it practically shifted the coast-line from the shores of Prussia and Holland to the westward of Britain and Ireland, at the same time interposing a powerful condenser of atmospheric moisture between Central Europe and the open water of the North Atlantic. If this opinion be correct, it is evidently a mistake to call the Loess "*post-Glacial.*" The character of the fauna it contains is indeed decisive upon this point, for, as Mr. Belt[1] insisted, "no more Arctic fauna is known in the basins of the Danube and the Rhine than that of the Loess." It seems likely, however, that as the Scandinavian and British ice grew and gradually occupied the basins of the Baltic, the German Ocean, and the Irish Sea, the precipitation of snow would be more confined to the west, and the glaciers of the north side of the Alps and of Central Europe would diminish for want of supplies. Therefore a considerable shrinking would take place in the latter region during the Loess period, and large tracts formerly covered by the ice would be laid bare; for, owing to the dryness and consequent clearness of the air, the sun in summer would be strong and brilliant, and the snow and ice would melt much faster than it could form again. The Loess would therefore succeed the Glacier in those parts, and would cover the beds of Boulder-clay and Gravel which the ice left behind it, and we might conjecture that in Central Europe the succession of stages would probably be as follows:—

1. A cold moist climate with the formation of peat and lignite beds, indicating the coming on of the ice (*Elephas meridionalis*).
2. The ice in possession of the surface, corresponding to the "Lemming stage" of Dr. Nehring.
3. A cold dry period with a climate like that of South Siberia, and a Steppe-fauna, resulting from the spread of the ice to the N.W. and its shrinkage to the S.E.

VI.—The Paste of Limestones.[2]

By J. G. Goodchild, F.G.S., H.M. Geol. Survey,

Lecturer on Geology and Mineralogy at the Heriot-Watt College.

Now that so close attention is being given to the microscopic investigation of rock structures, it is somewhat remarkable that no one should yet have questioned the validity of the views currently received regarding the exact constitution of limestone. Taking account only of those limestones whose original structure has not been obliterated by subsequent changes, the general view is

[1] Quart. Journ. Sci. Jan. 1887, "On the Loess of the Rhine and the Danube."

[2] Founded on communications to the Royal Physical and the Geological Societies of Edinburgh.

that nearly the whole mass, in the great majority of cases, is either directly, or indirectly, due to organic agencies. This view is even maintained in the cases where a microscopic examination of the rock fails to reveal more than a few traces of any structure that can be regarded as organic.

It is perfectly true that the exclusively-organic structure of the greater part of many limestones does not admit of any question. No one can doubt that fully 90 per cent. of the matter composing, for example, the shell-limestones of the Jurassic rocks, or the encrinital limestones of the Yoredale Series (which consist of masses of encrinites) must be of organic origin. But there are other limestones, often associated with these, of whose organic origin at all the evidence is by no means clear. Between these two extreme types every intermediate gradation exists. The fact, indeed, may be demonstrated by a careful study of the constitution of the different beds, or posts, of the same limestone, or even of the different laminæ composing the same bed. One such may consist almost entirely of organisms, fragmentary or otherwise; while those associated with it may exhibit hardly a trace of a fossil of any kind. In the case of certain shales associated with limestones, such for example as those of the Yoredale Rocks, the argillaceous bed may be crowded with organisms, while the calcareous bed immediately below may yield but a few traces of such; or else, in some cases, may consist of little else than an amorphous paste of carbonate of lime, in which neither microscopic examination, nor any other kind of investigation, reveals more than a few traces of organic structure.

Those writers who have occupied themselves with the study of limestones seem to have given but little attention to the nature and origin of this amorphous constituent of the rock. Perhaps one reason may be that those who have worked most at limestones have been specially interested in fossils, and have regarded the parts of the rock that did not exhibit traces of organic structure as comparatively devoid of interest. Even Dr. Sorby, in his well-known address on the origin of limestones, passes over this part of the subject with much less notice than one could have wished it should have received from him. He refers it chiefly to the crumbling down of the aragonite of calcareous organisms that were undergoing decomposition;[1] but part of it he refers to the detrition of older limestones, and part of it he regards as a chemical precipitate. Professor Prestwich (Geology, vol. ii. p. 320) suggests that the impalpable amorphous matter that forms so large a part of the Chalk, for example, "may really be a chemical precipitate thrown down under special and peculiar conditions prevailing at the time." Amongst other explanations is that based upon the fact that the seaward face of coral reefs is always undergoing considerable wear and tear under the action of breakers, and that much of the fine chalky matter resulting from this action is distributed far and wide

[1] On this subject see Vaughan Cornish and Percy F. Kendall, "On the Mineralogical Constitution of Calcareous Organisms," Geol. Mag. Dec. III. Vol. V. p. 66.

over the ocean-floor, where it subsides as a thin stratum of impalpable calcareous mud. Since the time that coral animals assumed the reef-building habit (which many think was not earlier than Mid-Tertiary times) such a factor must have been an important one in the production of the paste in question. Even in Pre-Tertiary times, before there were any coral reefs, the wear and tear of other calcareous organisms must have contributed to the same result. But as such action, from the nature of the case, must have been confined to littoral regions, it can hardly be taken much into account in dealing with the present question. It is quite clear in the case of the older limestone that the paste did not result from the detrition, on the spot, of the calcareous exuviæ existing on the sea-bottom; for, be the calcareous organisms what they may, they retain their original sculpturing, or other ornamentation, in as perfect a condition, so far as wear is concerned, as it was during the lifetime of the animals. In the course of several years' close study of everything relating to limestones, in the field and in the study, I have never yet come across a single instance where any evidence whatever of such attrition could be made out.

Another explanation sometimes given is that, when calcareous organisms have lain for any length of time on the sea-floor, they are attacked by chemical agencies, and are thereby dissolved more or less—the solution being, under different conditions, redeposited as a chemical precipitate. Without questioning the validity of this theory in particular cases, it will suffice to remind the reader that many of the facts tell strongly against such a view. When animals build up a calcareous framework, the carbonate of lime is invariably mixed with more or less organic matter, allied to chitin in many of its properties. The function of this substance, as Bischoff long since pointed out, is to enable the hard parts of the animals to resist the attacks of agents tending to bring about any such corrosion. As a matter of fact it is usually not until long after the animal has been dead, and its shell has been exposed to the attacks of subaërial erosion, that it begins to go to pieces at all. As a consequence, it is as rare to find a corroded shell, for example, in any limestone clearly of marine origin, as it is to find amongst recent shells the apex of an aged Gasteropod, or the umbo of a full-grown Lamellibranch, showing any sign of corrosion. It is only where the forces connected with subaërial denudation come into play that any such corrosion appears to be possible.

Another factor that may contribute to form some of the paste of limestone is the agency of certain fishes and molluscs that feed upon organisms secreting calcareous frameworks. Part, at least, of the finely-comminuted stony matter swallowed by these predatory animals is subsequently voided, and eventually subsides to the bottom. From the very nature of the case this can hardly ever have been of much importance in the present connection, although it cannot well be left altogether out of account.

Other explanations also have been from time to time advanced; but not one of them has proved altogether satisfactory.

The one explanation that would have satisfied all the requirements of the field geologist is, that the greater part, or the whole, of the paste in question is mainly due to chemical precipitation. But until quite lately chemists assured us that the facts then known did not warrant the assumption that any precipitation whatever of carbonate of lime was possible in the open sea. This view was mainly based upon the fact that all analyses of sea-water showed that the percentage of carbonate of lime held in solution was but a small fraction (a tenth, or thereabouts) of what sea-water was capable of dissolving. Therefore, it was pointed out, precipitation of carbonate of lime was simply impossible. That is no doubt perfectly true so far as it goes. But were the reactions that had been considered the only ones possible? More recent researches have shown that they are not. To these I shall refer in more detail presently. In this connection one very curious fact must surely have struck others engaged in teaching geology, as it struck me. In dealing with the enormous quantities of carbonate of lime that the rivers of the world are carrying seawards, one is called upon to explain how it happens that, off the mouths of those rivers, an analysis of the sea-water fails to show more than a trace of either carbonic acid or carbonate of lime. On the contrary, the composition of the sea-water there is practically identical with that of the ocean far from land. What has become of the carbonate of lime? We are told that it has been assimilated by organisms. That seems a reasonable explanation at first sight. But where *are* the organisms that effect this remarkable change so rapidly? Surely no one is prepared to maintain that the animals and the plants that build up organic carbonate of lime come to the mouths of rivers specially to obtain the supplies necessary for their purpose? The facts tell quite the other way. Indeed, the proportion of such organisms living just where river-water and sea-water mingle, to those living out at sea, is almost infinitely small. In other words, where carbonate of lime in solution is in excess, the percentage of organisms with calcareous frameworks is probably not as high as it is where the carbonate of lime is known to be deficient. If for that reason alone, it is quite clear that such an explanation is at fault.

If the carbonate of lime has not been extracted by organic agencies, then it must have disappeared through some reaction between the solutions of carbonate of lime in carbonated fresh water on the one hand and the saline constituents of sea water on the other. In other words, the carbonate of lime has passed into some other compound. What the exact nature of that compound is must be left to chemists to decide. But it is stated by Dr. Sterry Hunt, that if a solution of carbonate of lime in carbonated water be mixed with a solution of sulphate of magnesia in water, double decomposition ensues, and carbonate of magnesia and *sulphate of lime* are formed. Magnesian sulphate exists in sea-water in proportions, per 1000 parts of water by weight, varying from 2·20 to 6·40. If this is really in accordance with the results of modern researches, then we seem here to obtain a clue as to what is happening. The carbonate of lime brought seawards by rivers does not reach the sea as *carbonate*, but is poured unceasingly into the ocean as *sulphate of lime*. Hence the sudden disappearance of carbonate of lime at the point where river waters and the water of the sea meet.

That being the case, what becomes of all the sulphate? Sulphate of lime *is* present in all sea-water in proportions per 1000 parts by weight varying from 1·35 to nearly 4. But unless some agency is at work extracting this lime-compound from sea-water as fast as it is brought in, it is obvious that sulphate of lime would go on accumulating until the saturation point were reached, when precipitation would ensue. But, as all the researches that have yet been made have failed to bring to light the smallest proof of the existence of such precipitates in the open sea, it was an obvious conclusion that, in some way or other, the sulphate of lime was extracted by organic agencies, and that it was from this source, and not from carbonate of lime, that corals, molluscs, fishes,—in short, all marine organisms whose hard parts consisted of carbonate of lime,—obtained the supplies necessary for their purpose. And this was the view to which I had been independently led, and which was set forth in one of the papers referred to at the head of this article, without knowing that the fact had been actually demonstrated already.

The researches that led to the demonstration referred to were conducted near Edinburgh by Messrs. R. Irvine, F.C.S., and G. S. Woodhead, M.D., in 1888 and 1889. The results were made known in two papers read before the Royal Society of Edinburgh, the first in May, 1888, and the concluding part in May, 1889. They are published in the Proceedings of that body for 1888–9, part xvi. Their chief conclusions are of great importance to both biologists and geologists. The authors supplied various animals with different lime-compounds, singly, or in combination with other salts; and they proved by the results that organic beings possessed the power of decomposing all lime compounds during digestion, sulphate of lime amongst others; and that, through organic agencies, the resulting lime, entering into fresh combination with carbonic acid, and temporarily, also with phosphoric acid, is ultimately deposited and is left, while the phosphoric acid is apparently reabsorbed and is utilized afresh (*op. cit.* p. 340). In this way they consider "carbonate of lime may be secreted by marine animals, which have the sulphate of lime presented to them in the presence of chloride of sodium" (*ibid*, p. 350). And, lastly, they observe, "the carbonate of ammonia produced by the decomposition of urea, etc., decompos[es] a portion of the sulphate of lime of sea-water, with the formation of carbonate of lime equivalent in amount to the carbonate of ammonia thus formed" (*ibid*, p. 336). The papers referred to contain a valuable body of facts and observations relating to the formation of carbonate of lime by organic agencies other than those with which this paper is more directly concerned. But apart from these, the authors have unquestionably cleared away the principal mystery that has hitherto surrounded the origin of the organic constituents of limestones.

To return to the origin of the paste, with which Messrs. Irvine and Woodhead have not dealt:—It is a well-known fact that solutions of sulphate of lime in the presence of decomposing organic matter tend first to be reduced to the sulphide, and ultimately to be thrown down as a precipitate of carbonate of lime. In a paper on "Some Modes of Formation of Coal," read before the Royal Physical Society of Edinburgh, on April 17th, 1889 (published in the "Colliery Guardian," May, and, in a different form, in the GEOL. MAG. July, 1889), reference was made to this factor in connexion with limestones of inorganic origin. Such limestones would necessarily consist almost entirely of an amorphous calcareous paste in which animal organisms might or might not occur, although bituminous matter due to the partial or the complete decomposition of vegetable organisms might be present in variable quantity. In the field, limestones of this nature are of common occurrence in connection with beds of coal, as might be expected on the view of the origin of both these rocks advocated in the papers referred to. From such inorganic limestones a passage can readily be traced in one direction through clay ironstone, and blackband ironstone, into coal; while in the other direction (presumably that farthest from the land) such limestones gradually pass, by the addition of imbedded calcareous organisms, into limestones of the normal type. This led me, by inference drawn from another set of facts, to the conclusion that chemical precipitates, due to the reaction of decomposing organic matter upon sulphate of lime, have an essential influence upon the formation of limestones, even when these are mainly of organic origin. Wherever organisms are living, at that place also are other beings that are passing into the inorganic condition. In the case of those of marine habitat, it has been shown that these secrete carbonate of lime out of the sulphate of lime of sea-water while they are living; and the products of decomposition bring about a precipitate carbonate of lime from the same source when they are dead. Such action is not by any means necessarily limited to the tenants of the sea-floor, for the decomposition of pelagic organisms is likely to contribute more or less to the same result. Nor is it limited to organisms with calcareous frameworks, but may result just as much from the decay of, say, jelly-fishes, or sponges, as from their lime-secreting allies.

It is to this organico-chemical agency that I would refer the origin of the greater part of the paste of limestone of marine origin.

The shell-marl of lakes presents limestone paste under a somewhat different form. Even in this case the bulk of the rock is derived partly from the precipitation, by decomposing organic matter, of the carbonate of lime from the sulphate carried in solution into the lakes; partly from the precipitation of the carbonate of lime directly from solution by the withdrawal of part of the solvent carbonic acid by the agency of subaqueous vegetation; partly also by the actual decomposition of the shelly matter itself, under the corroding influences of the acidulated waters. Shells themselves, as a rule, of course, form but a small part of shell-marl.

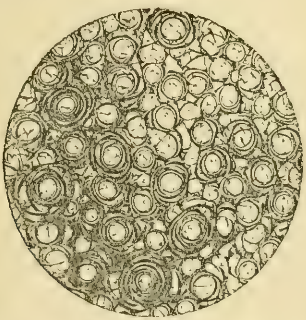
If the views here advocated find acceptance amongst geologists, it is clear that we shall have to regard all limestones as of compound origin, partly organic, partly detrital, partly as chemical precipitates —the proportion of each to the other varying greatly to a much greater extent than has yet been recognized.

VII.—On a Method of Producing Perlitic and Pumiceous Structures in Canada Balsam.

By Frederick Chapman.

THE interesting phenomenon exhibited in some glassy rocks, such as obsidians and pitchstones, known as the perlitic structure, consists of a series of rectilinear and curved cracks. It has been produced artificially in Canada Balsam, and described by Mr. Grenville A. J. Cole, F.G.S.[1]

Hitherto, any attempts of mine to produce the curved or secondary cracks on a glass plate were unsuccessful (the only result being primary cracks and appearances of air films between the glass and balsam); until noticing their occurrence on a rough mounting plate, it became evident that a *roughened* glass surface was the requisite thing in order to secure perfect cohesion. It is probable, therefore, that the specimen which Mr. Cole produced occurred on a ground portion of the glass plate.



For a cabinet specimen one cannot do better than to take a disc of glass of about $1\frac{1}{4}$ inches in diameter; or if it is wanted for microscopic examination it may be necessary to use a 3×1 slip. One surface of the glass is then ground on emery powder; meanwhile Canada Balsam is prepared in an evaporating basin by heating to brittleness. The balsam is taken whilst beginning to cool and poured on the glass, which has been slightly warmed to allow the balsam to flow without including bubbles. When the balsam has cooled slowly to a firm condition, but not quite cold, the plate is plunged into a vessel of cold water. Immediately this is done the rectilinear and subsequently the curved cracks appear throughout the entire layer of balsam. With a little care, very perfect and beautiful examples of the perlitic structure may be prepared in this way.

[1] On the Artificial Production of Perlitic Structure, Geol. Mag. Dec. II. Vol. VII. 1880, p. 115.

By various experiments it appears that the coarseness of the structure depends on, first, the thickness of the balsam heaped on the plate (when thinly spread the tendency is for the structure to be fine); second, the coarseness of the emery used in roughing the surface of the glass (fine flour emery generally giving rise to almost microscopic structure).

The illustration given is from a photograph of an actual specimen. The pumiceous structure, with its characteristic silky lustre, may be obtained by taking Canada Balsam made brittle by evaporation, and whilst in a soft condition stirred and beaten up with a thin strip of metal previously made warm to prevent the cooling of the balsam, until the soft mass is thoroughly permeated with air bubbles. It is then taken in a lump and pulled out several times, when the lustrous substance is obtained. This product resembles very closely the Schiller Obsidian of the Caucasus.

The above experiments were for the most part worked out in the Geological Laboratory of the Normal School of Science.

REVIEWS.

I.—A Manual of Palæontology for the Use of Students, with a General Introduction on the Principles of Palæontology. By Henry Alleyne Nicholson, M.D., D.Sc., F.G.S., etc., Regius Professor of Natural History in the University of Aberdeen, and Richard Lydekker, B.A., F.G.S., etc. Third Edition. Re-written and greatly enlarged. In Two Vols. Royal 8vo. pp. 1624, with 1419 Woodcut Illustrations. (William Blackwood & Sons, Edinburgh and London, 1889.)

THE contents of these two portly volumes fully bear out the authors' statement in the preface as to the rapid advance of palæontological science within the last ten years. When compared with the second edition issued in 1879, we find, notwithstanding the employment of somewhat smaller type and leads, an increase of 554 printed pages, whilst the number of the illustrations is nearly doubled. So great have been the changes and discoveries in the science within the last decade, that it has been found necessary to entirely rewrite and recast the whole; hence it has a just claim to be considered as a new work. The great development in the history of fossil Vertebrates within the last few years has also made it almost impossible for any one not a specialist to treat this branch of the science in a competent manner, and it is therefore a decided advantage to find that in this edition the description of the Vertebrates has been undertaken by Mr. R. Lydekker.

Not only, however, do these volumes indicate a decided increase in our knowledge of fossil organisms in recent years, but they also furnish satisfactory evidence of the improvement which has taken place in the character and methods of palæontological research, so that, whatever may have been its deficiencies in the past, palæontology has now a just right to recognition as a separate department of

Biology. It is still the fashion with some zoologists of the present day, whose studies are limited to recent organisms exclusively, to regard with lofty scorn the pretensions of palæontologists to be scientific in their aims and methods; but such pharisaic contempt is certainly undeserved by the present workers in this science, who are not content now, as in former times, with a mere description of the outer forms of fossils, but by means of sections and the microscope endeavour to ascertain all that can be known of the structure and relations of the organisms they study.

Taking into account the changes produced in fossilization, and the generally fragmentary condition of fossils, the task of the palæontologist in investigating extinct forms is far more difficult than that of the student of recent species, who has perfect materials at his disposal. As a rule, those who are purely zoologists seldom care to meddle with fossils, or, if they do, they frequently give abundant proof that something more than a knowledge of recent organizations is needed to interpret rightly the remains of extinct forms. It is fairly certain, that but for the work of those who have given their entire attention to fossil forms, but little comparatively would now be known of the life of the past, for the zoologist finds abundant recent material waiting for his study, and as this is more attractive and less difficult than the fossil, there is no temptation for him to forsake the recent for the study of past life.

Returning now to the Manual, we may note as one of the best features in this edition, the consideration given to the minute structure of the different groups of organisms. This, however, is limited to the Invertebrates; for though the microscopic structure of certain of the hard structures of fossil Vertebrates is of considerable importance in determining their affinities, there are no figures given of this in the second volume. It is of the greatest advantage to the student to be able to recognize in sections the nature of the organic fragments of which many rocks are largely composed, and it is sometimes as important to determine whether a rock consists of crustacean, echinodermal, or molluscan remains, as to know the particular genera or species which may be present in it. In this edition we are glad to see good figures of the minute structures of Foraminifera, Corals, Stromatoporoids, Echinoderms, Annelid tubes, Trilobites, etc. Aided by these the student is not likely to refer the plates and teeth of fishes to Stromatoporoids and fossil Sponges—a mistake which has been made in pre-microscopic days.

In spite of the greatly increased contents of these volumes, it is well to bear in mind the authors' statements that only the leading types of each great group of fossils have been selected for notice and characterization. To the student indeed the number of these leading forms might seem sufficient to embrace all that have been discovered; but the specialist, who knows something of the extent of his own particular department, is conscious of the great amount of condensation which has been necessary to keep the work within its present limits, and he possibly might find, here and there, reason to regret the brevity with which some subjects have been treated. There is no doubt, however, that the work furnishes the student with an excellent summary of the leading principles and facts of palæontological science—by far the most complete which has ever been published in the English language—and any one who wishes to gain either a general knowledge of the past life of the earth, or a guiding key to any particular division, cannot do better than make use of its assistance.

The first volume, for which Professor Nicholson is specially responsible, contains the General Introduction and the Invertebrata. It comprises 44 chapters, of which seven are devoted to the Introduction. The first part of this relates to the character and mode of formation of the sedimentary rocks, and the conditions under which fossils occur in them. Good figures are given of the microscopic structure of different varieties of fossiliferous limestones, including the White Chalk, which is compared with a section of the Globigerina mud from the depths of the Atlantic. Reference is also made to the organic siliceous rocks, such as flint and chert, which, as we now know, owe their origin to Sponges principally. Following a table of the chronological succession of aqueous rocks, full explanations are given of the migration of species, contemporaneity and homotaxis, the value to be attached to marine, as compared with land and fresh-water fossils; geological continuity, life-zones, and the now obsolete doctrine of intercalated colonies. In the succeeding chapter the causes of the imperfections of the Palæontological Record are pointed out, and some remarks made on the theory propounded by Murray and Rénard that there are no geological representatives of abyssal deposits. It is evident, however, that certain portions of the sedimentary series fully correspond with the Foraminiferal ooze, the Radiolarian ooze, the Diatom ooze, and even with the Pteropod ooze, and it is by no means improbable that some of the variegated, fine-grained muds of the Cambrian and Ordovician strata may correspond to the abyssal clays of the present oceans. The question of the climatic conditions of the earth in former geological periods is also one on which no certain conclusions can be drawn from fossils—at all events on those from the older rocks; but the researches of Neumayr on the animal life of the Jurassic period indicate the existence at that epoch of climatic zones similar to those of the present day, and there is also a certain amount of evidence of the recurrence of Glacial periods at different epochs in the past.

As regards the terms used in palæontology, the author remarks that they are the same as those employed by the zoologist; but owing to the fact that as almost without exception the specific characters of fossils must necessarily be founded on the hard structures only, and these often imperfectly preserved, it follows that a palæontological species cannot be expected to have the same value as that which a zoological species ought to have when the entire structure of the organism can be taken into account, and consequently both the species and the genus must be accepted in a wider and less strict sense in palæontology than in zoology. The author adopts the definition of a palæontological species given by von Zittel, viz. that it comprises all those individuals, or remains of individuals, which possess in common an assemblage of constant characters, and which constitute collectively a distinctly circumscribed morphological series, apart from all considerations relating to their range in time and in space.

The final chapter of the Introductory part treats of the Evolution of Organic Types in time. The author points out that we are quite ignorant of the animals and plants which constituted the first living beings, and that we are likely to remain so; that representatives of all the invertebrate sub-kingdoms are present in the earliest fossiliferous deposits, and these as individuals are complex and highly specialized in their structures, and we are bound to conclude that these earliest known faunas must have been preceded by many others altogether unknown to us, in which the gradual changes from the primitive simpler types of life took place. Throughout the entire geological succession we can note a continuous introduction of new species, sometimes gradually, at others apparently very abruptly, but the evidence of palæontology points to the operation of some general law of evolution, by which these new species have been derived from pre-existing forms. This succession of life-forms is further progressive in character, the evidence of palæontology indicating a distinct advance in complexity of organization of the later as compared with the earlier morphological types. There is but little chance of ascertaining from the rocks any knowledge of the order of the appearance of the different leading types of Invertebrates; but we ought to be able to find traces of the first appearance of the higher classes of Vertebrates. The author remarks that there is no *direct* palæontological evidence which would certainly establish any particular theory as to the precise mode in which this law of evolution has been carried on, nor is the evidence from this source conclusive as to the theory of the origin of species by natural selection. Whilst it is true that in a certain number of instances it has been found possible to connect two different specific types by means of a long series of intermediate links, as a general rule, the known transitional forms between allied groups are few in number. "It cannot be doubted, therefore, that palæontology has, so far, to a large extent, failed to bring forward the numerous and *closely graduated* series of intermediate forms which must at one time have existed, supposing 'natural selection' to be the sole agent in the origination of new species. The absence of a sufficient number of such transitional forms, and the insufficient connection between such as are known to exist, may doubtless be in part explained by the known 'imperfection of the geological record'; but this does not appear to offer an adequate solution of the difficulty. The theory of the 'origin of species by means of natural selection,' as elaborated by the master-mind of Darwin, constitutes nevertheless an invaluable, indeed, an indispensable guide in all branches of palæontological research."

The greater part of the first volume treats of the palæontology of the Invertebrata. We can within the limits of this notice only refer to some of the changes and additions which appear in this new edition. In Foraminifera, for instance, there is introduced the new arrangement into families proposed by Dr. H. B. Brady, in the "Challenger" Report, in which the structure of the test as an exclusive basis of classification has been abandoned. Figures are given of some of the peculiar forms of the recent Astrorhizidæ, in which the test consists of arenaceous tubes, and to these the peculiar genus *Girvanella*, lately shown to occur in many limestones from the Cambrian to the Jurassic, is thought to be allied. The group of the Dactyloporidæ, formerly included with the Foraminifera, now finds its place with the Algæ. In an Appendix, several pages are devoted to a consideration of the structure of *Eozoon*, which the author has investigated for himself, and some excellent woodcuts, drawn from the author's own sections, convey a very good idea of the microscopic appearance of this peculiar substance. Professor Nicholson by no means rejects as inadmissible the idea of its organic origin, but thinks that "until mineralogists or petrologists are able to point, in some unquestionable mineral or rock, to a structure strictly comparable with the 'canal system' of *Eozoon*, they are not entitled to assert positively that the latter has a purely inorganic origin." But a similar argument is applicable to those who assert its organic origin, although no organism is known with a canal system strictly comparable to this alleged structure in this rock. It is to be hoped that the active investigation now in progress as to the origin of the rocks in which *Eozoon* occurs, may help to decisively solve the problem as to its real character.

In the chapter on Radiolaria, an outline is given of Haeckel's new classification, and mention made of the presence of these organisms in Jurassic strata where they form beds of jaspery chert. As the microscopic structure of the siliceous organic rocks is better known, this group will most likely appear more important as a rock-former than has hitherto been supposed.

The Sponges, which in the last edition were included under Protozoa, are now placed in a separate sub-kingdom—the Porifera—intermediate between Protozoa and Cœlenterata. They are divided into two classes: the Plethospongiæ, embracing the siliceous and horny forms, as well as those without any hard skeleton, and the Calcispongiæ. Our knowledge of the organization and distribution of the fossil Sponges has greatly extended within the last decade; but owing to the liability of their skeletons to break up, we are still ignorant of the complete forms of many of the older types, and these can at present only be determined by their scattered spicules, which are numerous enough to form considerable thicknesses of rock, more particularly in the Carboniferous epoch. The family of the Receptaculitidæ is, on Hinde's determination, included with the siliceous sponges; but Dr. Rauff, as mentioned in the Appendix, questions the correctness of this reference, though he is unable to refer this puzzling group to any other division of the Animal Kingdom.

Fossil Calcisponges are now known to have a wide distribution and to be abundant in Jurassic strata; their very existence as fossils was denied up to a very recent period; on the other hand, forms formerly referred here, such as the Stromatoporoids, are now placed in the Cœlenterata.

The Archæocyathinæ, from the Cambrian strata of Europe and America, are regarded as of doubtful affinities; but recent researches show that they possess a considerable resemblance to Madreporarian Corals. The real nature of *Pasceolus, Cyclocrinus,* and *Nidulites* is still uncertain.

Coming now to the Hydrozoa, there are good figures of *Hydractinia* and *Parkeria,* and also of the peculiar genera *Mitcheldeania* and *Solenopora,* which form an important part of many Palæozoic limestones. *Oldhamia* is still retained with the Hydroida, though its nature is open to great doubt.

Passing over the Graptolites, of which several new figures are given, we reach the Hydrocorallines and Stromatoporoids, and, as might be expected from the author's researches in this latter group, their structural features are clearly described and illustrated. They are considered as forming a special and now unrepresented group of Hydrozoa, some forms having relations to the recent Hydractinia, and others to Hydrocorallines like *Millepora.*

Considering the importance as fossils of the Actinozoa or Corals, we are glad to note the greatly increased space devoted to them in this edition, so that their general features, different modes of growth and increase, and more particularly their minute structural characters, are treated fully, and well shown in the elaborate figures, most of which are original. It is acknowledged that the classification of this group is in a transitional state, and that the position of the Rugosa as a separate order cannot be maintained; but it is still kept distinct, and with the Aporosa, Fungida and Perforata, form the primary sections of the Madreporaria. There can be little doubt however, that many, if not most of the Rugosa will enter into the division of the Aporosa. One of the principal grounds of distinction was based on the supposed tetrameral development of the septa, but the importance of this has been overestimated, and we find here that the Coral, *Stauria astræiformis,* in which this tetrameral arrangement is most conspicuously shown, has been removed from the Rugosa and placed with the Astræida in the Aporosa.

To the section of the Madreporaria Perforata, previously regarded as almost exclusively Mesozoic and Tertiary, considerable additions have been lately made from the older rocks. Thus we have the genus *Calostylis* from the Wenlock, *Cleistopora* from the Devonian and *Palæacis* from the Carboniferous; whilst the great family of the Favositidæ, formerly in the now obsolete group of the Tabulata, also finds its place in this division. Though somewhat more aberrant in their mode of growth, the Syringoporidæ and the Thecidæ are likewise included in the Perforata.

The Palæozoic families of the Heliolitidæ and the Halysitidæ are placed with Alcyonarian Corals on account of their presumed relationship to the recent *Heliopora.* It is, however, pointed out that their minute structures are widely different, and that the autopores or corallites generally possess a constant number of septa. Other differences might also be mentioned, and there is room for doubting whether the interstitial tubes in these old fossils were tenanted by rudimentary polypes as is stated to be the case in *Heliopora*; for in the genus *Plasmopora* the intermediate tissue is vesicular instead of tubular in character. In many respects the Corals of these families show a relationship to *Syringopora.*

Considerable advance in our knowledge of the microscopic structure of fossil Corals has been lately made, and it seems likely that in any fresh classification the minute structure of the walls and septa will have to be taken into account as an important feature in the relationship of different forms. The significance of this is well shown in the figures given on page 247 of transverse sections of a recent *Caryophyllia,* and of two Palæozoic Corals, *Streptelasma* and *Zaphrentis,* in which the structure and arrangement of the septa are essentially similar in all, though in the present accepted classification the former genus is widely separated from the latter.

Some important remarks are contributed on the nature of coral reefs, and the difficulty is pointed out of determining whether the outcrops of coral limestones in the older rocks really represent the boundaries of coral reefs comparable to those now in process of formation.

A group of organisms, the Monticuliporoids, very numerously represented in Palæozoic rocks, and about whose affinities much uncertainty rests, are treated in a separate chapter. These forms have been more especially studied by the author, who regards them as probably Corals, but other authorities consider them to be Polyzoa. Waagen has lately stated that the mode of increase in some of these forms is by cœnenchymal gemmation, like that of some undoubted Corals, but there is reason to doubt the accuracy of this observation, and it is likely that the mode of growth, in some of the Fistuliporidæ at least, is similar to that in Polyzoa.

The sub-kingdom of the Echinodermata is considered in the Chapters xxii. to xxvi. Good figures are given of the minute structure of the skeleton, so characteristic of the whole group, and reference made to the distinctive cleavage which reveals at once the presence of these organisms in the rocks. The group is ranged under two divisions: the Echinozoa, which includes the Echinoids, Asteroids Ophiuroids and Holothuroids; and the Pelmatozoa embracing the Crinoids, Cystideans and Blastoids. Important additions are made in all these divisions in the present edition, more particularly in the Crinoids and Blastoids. The former class is divided into Neocrinoids and Palæocrinoids; but owing to recent discoveries in the structure of *Encrinus* and *Taxocrinus,* this arrangement will have to be abandoned, and the classification of Wachsmuth and Springer, modified by Dr. P. H. Carpenter, will take its place. In this, the Crinoids are divided into three orders: the Coadunata, Inadunata, and the Articulata. In the Blastoids, the divisions into the two primary orders of Regulares and Irregulares, proposed by Etheridge and Carpenter, are adopted. The long extinct Cystideans present considerable difficulties in their arrangement. In the Appendix, Dr. Carpenter contributes a note on certain structural points of some of the Bohemian forms described in Barrande's posthumous work on this group.

In the chapter on fossil Annelids, the microscopic structure of some of the Tubicolæ is figured, as well as that of the peculiar *Cornulites* from the Wenlock. Some of the minute chitinous jaws of the Ordovician Polychetæ are also shown.

Barrande's classification of the Trilobites is adhered to, but it seems that even in this group no strict zoological arrangement is as yet possible; it is regarded as more nearly related to the Merostomata than to any other division of the Crustacea. Figures are given of the minute structure of the test, and also of the appendages discovered by Walcott on the under-surface of the body of *Asaphus*.

Under the Arachnida, interesting figures are given of the structure of the chitinous skin of a fossil Scorpion from the Carboniferous rocks of Scotland, and of a recent specimen of this group.

Several new figures of the minute structure of the Polyzoa and of the beautifully-marked cells of the Cheilostomata are added in this edition. The peculiar form of the cell-apertures in *Coscinium cribriforme* (p. 610), and in *Cystodictya Gilberti* (p. 631) is very suspiciously like those of the Monticuliporoid *Fistulipora trifoliata* (p. 358), and might lead one to suppose a near relationship between these forms.

Owing to the comprehensive labours of the late Dr. Davidson, there are fewer changes in the Brachiopoda than in other groups. The principal novelties are the forms from the Carboniferous strata of India, described by Waagen under the names of *Oldhamina* and *Lyttonia*.

In the Lamellibranchiata, Fischer's new classification is adopted in preference to the former one based on the presence or absence of siphons. As becomes the importance of this group, most of the representative types are figured.

The old divisions of the Gasteropoda into the Pulmonata and Branchiata are maintained, but the Chitons and Dentaliidæ are regarded as forming two separate classes of Mollusca. In the Pteropoda, the delicate calcareous tubes known as *Styliola fissurella* are believed to be genuine representatives of the group. Some of the Devonian Limestones in North America are almost exclusively composed of these small tubes; the section figured shows this remarkably well. *Tentaculites* is still retained in the Pteropoda, but the structure of its shell throws considerable doubt on its relationship to this group.

The concluding four chapters of this volume treat of the Cephalopoda. Many additional figures illustrate their structure and early stages of growth. In the Nautiloidea the family divisions lately proposed by Foord are adopted, and the Ammonites are arranged according to the classification of von Zittel.

(*To be continued.*)

II.—Proceedings of the Cotteswold Naturalists' Field Club for 1888–1889, Vol. IX. Part 4.

THE Cotteswold Club continues its good work, notwithstanding the heavy losses it has sustained of late years, by the death of Wright, Guise, Witchell, Lees, and Symonds. Excursions have been made to Cheddar, Edgeworth, Crickley and Tetbury, but though old hunting-places are revisited, yet, as Mr. W. C. Lucy (the President) remarks, "there is ample ground for more detailed work, which can only be accomplished in a satisfactory manner by those who live, like our members, in the area." Moreover, "The subject has become so vast as to make it necessary to divide its study into many parts; and hence, instead of the naturalist of broad general knowledge, there will inevitably spring up specialists who will work in various departments, and the mere 'all-round man' will soon be a fossil of the past."

The number of original workers in any society or field-club is but small compared with those generally interested in the pursuit of science and who are content to follow in the footsteps of others. To this larger body of enthusiastic students geology is mainly indebted for its support. We have been told that among those who contribute most largely to the "talus-heap of geological literature," there are some who affect almost to disregard the writings of others; but they are apt thereby to burden the 'talus' with needless contributions, like the individual in "Punch" who never read books; he *wrote* them. If the original worker finds the productions of others very dry, what must be the feelings of the ordinary student! Probably, as a rule, insufficient attention is given by those who write papers to the wants and capacities of the would-be reader. If the work of the specialist is intended only for specialists, the results can be known to but few, and the enthusiasm of the general student will be damped by his inability to keep up with the progress of the science. We feel this in glancing over the list of fossils in Mr. S. S. Buckman's paper on "The relations of Dundry with the Dorset-Somerset and Cotteswold areas during part of the Jurassic period." The familiar *Rhynchonella spinosa* appears under the name of *Acanthothyris spinosa*, and other well-known forms are obscured by the new generic titles of *Glossothyris*, *Dictyothyris*, *Zeilleria*, *Aulacothyris* and *Plesiothyris*. Surely science is hindered by the prominent use of these subgeneric names, which are of biological but not geological interest, and are only of service as working-material to the specialist. Again, in a list of Ammonites, 22 species are recorded under 11 subgeneric names, some of which moreover have undergone repeated changes. As these names can convey a clear meaning to few besides specialists, we regret that they were not placed in brackets after the ordinary generic name.

We have dwelt on this subject, as the nomenclature adopted by Mr. Buckman renders it difficult to follow his arguments. He endeavours to show that the Inferior Oolite, of which Dundry is mainly composed, was in its lower portion connected intimately with the Dorset and South Somerset area, while only the upper portion or *Parkinsoni*-zone was connected also with the Cotteswold area. He believes that a barrier was raised "*after* the deposition of the Lower Lias and just before that of the Cotteswold Sands," and that this barrier, for a time, disconnected the Bath and Cotteswold area of deposit from that of Dundry and the Dorset area. From the evidence brought forward this may be taken as an interesting and important suggestion made to explain certain palæontological differences between the strata in the respective areas.

Mr. Lucy contributes "Remarks on the Dapple Bed of the Inferior Oolite at the Horsepools, and on some Pebbles from the Great Oolite at Minchinhampton." The Dapple bed is the quarrymen's name for a layer of Oolite that contains tiny quartz pebbles, and also pebbles of Oolite distinguished from the matrix by a difference in colour and texture. These latter, as Mr. Lucy remarks, evidence "the destruction of older rocks of the same nature during, or previous to, the deposition of the existing Oolite;" while the quartz pebbles he considers to have been derived from the Forest of Dean. The pebbles said to have been obtained from the Great Oolite had, in Mr. Lucy's opinion, been derived from the Drift, but had dropped down a fissure in the Oolite.

The Rev. H. H. Winwood furnishes "Notes on a Geological Section between Tytherington and Thornbury." A very neatly-drawn coloured section accompanies the paper; and it may be mentioned that this differs in some minor particulars from the section published by Prof. Lloyd Morgan (Proc. Bristol Nat. Soc. vol. vi. part i.). The section depicts the cuttings on a new line of railway, and shows the Old Red Sandstone passing upwards through the Lower Limestone Shales into the Carboniferous Limestone. Full details of the strata are given by Mr. Winwood. At one point a reversed fault brings fine-grained beds of Dolomitic Conglomerate (like Magnesian Limestone), beneath the Carboniferous Limestone. Other sections show Dolomitic Conglomerate, Keuper Marl and Sandstone; and altogether the making of the railway has furnished a very instructive series of cuttings. H.B.W.

III.—Structures et Classification des Roches Éruptives. *Par* A. Michel Lévy. pp. 95. (Paris, 1889.)

THIS is primarily a spirited attack on the principles laid down by Rosenbusch in his *Mikroskopische Physiographie der massigen Gesteine*, and a revindication of those already set forth by the author in conjunction with Fouqué. Though perhaps stronger on the critical than on the constructive side, this little volume is full of fertile suggestions, and is certainly the clearest exposition of the views of the French school which has yet appeared.

The author maintains that the plutonic (*granitoïde*) rocks, no less than the volcanic and porphyritic (*trachytoïde*), present evidence of two distinct periods of crystallization, the products of which may be easily discriminated; but that in the former class the minerals of the two periods have similar characters, while in the latter they are dissimilar. To account for the complex structures of the acid rocks, he has recourse to the *agents minéralisateurs* to which French petrologists from the time of Élie de Beaumont have attached so much importance.[1] He ascribes all the differences of structure that can arise from a magma of given composition to variations in the three factors, temperature, pressure, and 'mineralisers,' and considers that in the structure of the basic rocks the first of these factors has had a dominant influence. Indeed he seems to imply that the order of crystallization of the constituents of these rocks depends in general on their relative fusibility, the initial temperature of the magma, and its successive more or less sudden variations. In this connection he cites the synthetic experiments of M. Fouqué and himself, which perhaps have not received due appreciation at the hands of geologists in general.

Our author strenuously denies the generality of the rule which associates the granitoid types of structure with deep-seated igneous rocks and the porphyritic and allied types with extravasated products, and quotes a number of instances in opposition to it. The citation of the Tertiary gabbro 'domes' of the Hebrides as analogous to the *puys* of Auvergne seems to rest on a misunderstanding of Dr. Geikie's description, and in any case the exceptional occurrences mentioned are scarcely sufficient to overthrow so general a law.

The second chapter is devoted mainly to a discussion of the minute structures of rocks and a comparison of the French and German views of the nature of 'petrosilex,' and the various centric and spherulitic structures of the acid series. From the concluding remarks we gather that the author definitively abandons the age, or presumed age, of igneous rocks as a principle of classification, and his observations in this connection will certainly commend themselves to English petrologists.

In the next chapter M. Michel Lévy considers the mineralogical constitution of igneous rocks, especially as an exponent of their chemical composition. He shows that by selecting as a basis of classification of the porphyritic rocks the elements of the first period of consolidation Rosenbusch has been led into a scheme of arrangement which accords but very imperfectly with the bulk-analyses of the rocks. He prefers to take account more particularly of the dominant 'white' (*i.e.* non-ferriferous) constituents of the second period of consolidation, which afford a more accurate index of the chemical composition of the rock. To elucidate his views he introduces a system of formulæ designed to express at once the structure of a rock, its mineral constituents, their order of consolidation, and their division into two periods of consolidation.

In the fourth chapter we have a detailed study of Rosenbusch's classification of eruptive rocks, and the artificial character of some of his divisions is clearly exhibited. Our author further taxes the leader of the German school with altering the meaning of well-established descriptive terms and often overlooking the prior claims of the nomenclature proposed by French petrologists, and it is impossible to deny that this protest is in many instances a just one.

While all geologists will sympathize with M. Michel Lévy's desire

[1] Cf. de Lapparent, Bul. Soc. Géol. Fr. (3) xvii. p. 282; 1889.

for a classification of igneous rocks which shall be *natural* and so independent of all hypotheses, many will doubt whether such a system is yet possible. Any well-established facts connecting particular types of rocks with special modes of occurrence, depths of consolidation, or even succession in geological time or restriction within 'petrographical provinces,' might well claim to be taken into account in a natural classification; but are geologists agreed on any of these points? M. Michel Lévy replies in the negative. The Wernerian heresy, from which the German petrologists have not yet fully recovered, had it been true, would have afforded an impregnable system of classification. Other systems, such as von Richthofen's 'natural classification of volcanic rocks,' have been founded on a similar assumed generality of a local succession. If future researches should bring to light general principles which will stand the test of particular applications, petrology will certainly be placed on a more philosophical footing. Meanwhile a classification like that of our author, founded on mineralogical and structural characters, the ultimate causes of which are only vaguely foreshadowed, cannot, however useful, claim to be a natural one.

The author is of opinion that the mode of occurrence of eruptive rocks is not sufficiently closely connected with their structure to be taken into account in a rational classification; but when he attacks the current division between plutonic and volcanic rocks, his position is seriously weakened by his admission that such a grouping agrees in the main with his own, founded on purely structural characters. Again, the intermediate class of 'dyke-rocks,' to which he also objects, appears in practice to be a very convenient one. Whether its limits, as defined by Rosenbusch, are well chosen, is a different question. Doubtless some geologists would prefer to include in it the diabases, which, as structurally distinguished from the dolerites, are characteristically found in dykes, sills, and small laccolites: others, with M. Michel Lévy, would exclude some of the so-called acid *ganggesteine*.

Our author expresses a hope that his somewhat *bizarre* symbolic notation may serve to bridge over the gap pending a unification of petrological nomenclature; but it appears a little complex and very likely to suffer in hasty writing, and it may be doubted whether it will commend itself to the geologist any more than to the printer. In the tabular exposition of the classification of Fouqué and Lévy, however, it gives a degree of precision which would not otherwise be attainable without lengthy descriptions. A. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Dec. 18, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Occurrence of the Genus *Girvanella*, and remarks on Oolitic Structure." By E. Wethered, Esq., F.G.S.

The author referred to his previous work, wherein he had shown that *Girvanella* is not confined to Silurian rocks, and that as a rock-forming organism it is more important than was supposed, occurring in the Gloucestershire Pea-grit, and also in the Coralline Oolite of Weymouth. He now dealt more in detail with its occurrence (1) in the *Carboniferous Oolitic Limestone*; and (2) in the *Jurassic Oolites.*

In the Carboniferous Limestone of the Avon valley, oolitic limestone occurs on four horizons, in three of which the oolites rest on dolomite. In none of these three cases are there signs of *Girvanella.* From beds partly oolitic, and not resting on dolomite, he has been able to determine two new species. The oolite not associated with dolomite is less crystalline, and the original structure is better preserved.

In referring to *G. pisolitica*, he discussed whether *Girvanella* is most allied to the "Challenger" Foraminifer, *Hyperammina vagans*, or to *Syringammina fragilissima.* Traces of the organism occur in the *Clypeus*-grit, but none are quoted from the beds of the Great Oolite, nor from the Portland Oolite. The author had already shown that the pisolites in the Coralline Oolite of Weymouth were not concretions, but forms of *Girvanella.* Excluding these, he showed that the spherules are of four types, of which one is the ordinary oolitic granule, while each of the others suggests the presence of *Girvanella.*

The characters of the genus, as seen under the microscope, were indicated, and four new species were described.

2. "On the Relation of the Westleton Beds or 'Pebbly Sands' of Suffolk to those of Norfolk, and on their extension inland, with some observations on the Period of the final Elevation and Denudation of the Weald and of the Thames Valley." Part II. By Prof. Joseph Prestwich, M.A., D.C.L., F.R.S., F.G.S.

The author having, in the first part of this paper,[1] discussed the relationship of the Westleton Beds to the Crag Series and to the Glacial Deposits, proceeded in the present contribution to consider the extension of the Westleton Beds beyond the area of the Crag, and described their range inland through Suffolk, East, West, and South Essex, Middlesex, North and South Hertfordshire, South Buckinghamshire. and North and South Berkshire, noticing their relationship to the overlying Glacial beds, where these were developed, and the manner in which they reposed upon older deposits. He gave an account of the heights of the various exposures above Ordnance Datum, and mentioned the relative proportion of the different constituents in various sections, thus showing that in their southerly and westerly extension they differed both in composition and in mode of distribution from the Glacial deposits. Distinction was also made between the Westleton Beds and the Brentwood Beds.

Attention was next directed to the occurrence of the Westleton Series south of the Thames, in Kent, Surrey, and Hampshire, and their possible extension into Somersetshire was inferred from the character of the deposits on Kingsdown and near Clevedon.

In tracing the deposits from the east coast to the Berkshire

[1] Proc. Geol. Soc. June 5, 1889.

Downs, it was noticed that at the former place the beds lay at sea-level, but ranging inland, they gradually rose to heights of from 500 to 600 feet; that in the first instance they underlay all the Glacial deposits, and in the second they rose high above them, and their seeming subordination to the Glacial series altogether disappeared; thus at Braintree, where the Westleton Beds were largely developed, they stood up through the Boulder-clay and gravel which wrapped round their base, whilst further west, where they became diminished to mere shingle-beds, they attained heights of from 350 to 400 feet, capping London-clay hills, where the Boulder-clay lay from 80 to 100 feet lower down the slopes, the difference of level between the two deposits becoming still greater in a westerly direction, until finally the Boulder-clay disappeared.

The origin of the component pebbles of the beds was discussed, and their derivation traced (1) to the beds of Woolwich age in Kent, N. France and Belgium, and possibly to some Diestian beds, (2) to the older rocks of the Ardennes, (3) to the Chalk and older drifts, and (4) to the Lower Greensand of Kent and Surrey, or in part to the Southern drift.

The marine nature of the beds was inferred from the included fossils of the type-area, and the absence of these elsewhere accounted for by decalcification.

The southward extension of the beds was shown to be limited by the anticlinal of the Ardennes and the Weald, and the scanty palæontological evidence of the nature of that land was noted, and the possible existence of the Scandinavian ice-sheet to the north was referred to in connexion with the disappearance of the beds in that direction.

From the uniform character of the Westleton shingles the author maintained that they must originally have been formed on a comparatively level sea-floor, and that the inequalities in distribution had been produced by subsequent differential movement to the extent of 500 feet or more to the north and west above that experienced to the east and south, where the chronological succession remained unbroken, also that the inequalities below the level of the Westleton beds had been produced since the period of their deposition, as, for instance, the gorge of the Thames at Pangbourne and Goring, and most of the Preglacial valleys in the district; furthermore, evidence was adduced in favour of the formation of the escarpments of the Chalk and Oolites since Westleton times, whilst certain observations supplied data for estimation of the relative amounts of pre- and post-glacial denudation of the valleys.

It was stated, in conclusion, that the time for the vast amount of denudation was so limited that it was not easy to realize that such limits could suffice, but the author did not see how the conclusions which he had arrived at could well be avoided.

II.—January 8, 1890.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On some British Jurassic Fish-remains referable to the Genera *Eurycormus* and *Hypsocormus*." By A. Smith Woodward, F.G.S.

Hitherto our knowledge of the Upper Jurassic Fish-fauna has been mainly derived from specimens found in fine lithographic stones, where the various elements are in a state of extreme compression. Within the last few years remains of similar fish have been discovered in the Oxford and Kimeridge Clays in England, and these are of value for precise determination of certain skeletal features in the genera to which they belong.

The author described *Eurycormus grandis* from the Kimeridge Clay at Ely, a large species which makes known for the first time the form and proportions of several of the head-bones in this genus. A technical description of all the bones the characters of which are distinguishable was given, and the author concluded that there is considerable similarity between the head of *Eurycormus* and the recent Ganoid *Amia*, even to minute points of detail.

He further described *Hypsocormus tenuirostris* and *H. Leedsii* from the Oxford Clay of the neighbourhood of Peterboro', the osteology of this genus not having as yet been elucidated. Portions of the jaws have been discovered, affording valuable information as to the form and dentition of the principal elements.

These jaws are not precisely paralleled by any other Jurassic genus, though they possess a resemblance to *Pachycormus*, as also to the Upper Cretaceous genus, *Protosphyræna*.

2. "On the Pebidian Volcanic Series of St. Davids." By Prof. C. Lloyd Morgan, F.G.S.

The Relation of Pebidian to Cambrian.—There are four localities where the junction is described—Caerbwdy Valley, St. Non's Bay, Ogof Golchfa, and Ramsey Sound. The stratigraphy of the second of these was given with much detail, and illustrated. The author concluded that here, together with clear signs of local or contemporaneous erosion, the general parallelism of the strike of Pebidian and Cambrian is most marked. There is no evidence of any bending round of the conglomerate against the strike of the Pebidians. The stratigraphical evidence in each of the localities having been considered, together with the evidence offered by the materials of the Cambrian conglomerate and local interstratification with the volcanic beds (the interdigitation at Carnarwig being well marked), he concluded that there was no great break between the conglomerate and the underlying Pebidians. The uppermost Pebidian already foreshadowed the sedimentary conditions of the Harlech strata, and the change emphasized by the conglomerate was one that followed volcanic conditions after no great lapse of time.

Hence the relation of the Pebidian to the Cambrian is that of a volcanic series, for the most part submarine, to succeeding sedimentary strata—these strata being introduced by a conglomerate formed in the main of foreign pebbles borne onward by a current which swept the surface of, and eroded channels in the volcanic tuffs and other deposits. He was disposed to retain the name Pebidian as a volcanic series in the base of the Cambrian system.

The Pebidian Succession.—With the exception of some cinder-beds, which appear to be subaerial, the whole series was accumulated under water. There is no justification for making separate subdivisions; the series consists of alternating beds of tuff of varying colour and basicity, the prevailing tints being dark green, red-grey, and light sea-green. In the upper beds there is an increasing amount of sedimentary material, and more rounded pebbles are found. Basic lava-flows occur, for the most part, in the upper beds. Detailed work, laid down on the 6-inch Ordnance Map, appears to establish a series of three folds—a northern anticline, a central syncline, and a southern anticline—folded over to form an isocline, with reversed dips to the S.E. The axis of folding is roughly parallel to the axis of St. David's promontory. The total thickness is from 1200 to 1500 feet. The author had failed to find the alleged Cambrian overlap. "The probabilities are that it is by step-faults between Rhoson and Porth Sele, and not by overlap, that the displacement of the conglomerate has there been effected." Also at Ogof Gôch it does not rest upon the quartz-felsite breccia and sheets (group C of Dr. Hicks), but is faulted against them. A section was devoted to the felsitic dykes, and it was suggested that they may be volcanic dykes of Cambrian age.

The Relation of the Pebidian to the Dimetian.—The author has not been able to satisfy himself of the existence of the Arvonian as a separate and distinct system. He notes the junction of Pebidian and Dimetian in Porthlisky Bay and the Allen Valley at Porth Clais, at neither of which places are there satisfactory evidences of intrusion. At Ogof Llesugn the intrusive character of the Dimetian was strongly impressed upon him. He criticized the mapping of Dr. Hicks, and pointed out the difficulties which present themselves in the way of mapping the Dimetian ridge as Pre-Cambrian. He pointed out that not a single pebble of Dimetian rock, such as those now lying on the beach in Porthlisky Bay, is to be found in the conglomerate. He concluded that the Dimetian is intrusive in the southern limb of the isocline, and that there are no Archæan rocks *in situ*.

OBITUARY.

EUGENE EUDES-DESLONGCHAMPS.

BORN 1830; DIED 1889.

WE regret to have to record the death of M. Eugene Eudes-Deslongchamps, which occurred at Chateau Matthieu, Calvados, on the 21st of December, 1889. M. E. Eudes-Deslongchamps, who was born in 1830, early took an interest in scientific pursuits, and at the age of twenty-three joined the Linnean Society of Normandy, of which his father M. J. A. Eudes-Deslongchamps was one of the original founders; he became at once a regular contributor to the Society's Bulletin, and though he commenced work with ornithology, this group did not long monopolize his attention, his writings at this period dealing with Jurassic Geology, the Cirripedia, Mollusca, Brachiopoda, and an elaborate memoir on the Fossil Mammalia of Caen. In 1856 he published, in conjunction with his father, a French translation of the Introduction to Davidson's British Fossil

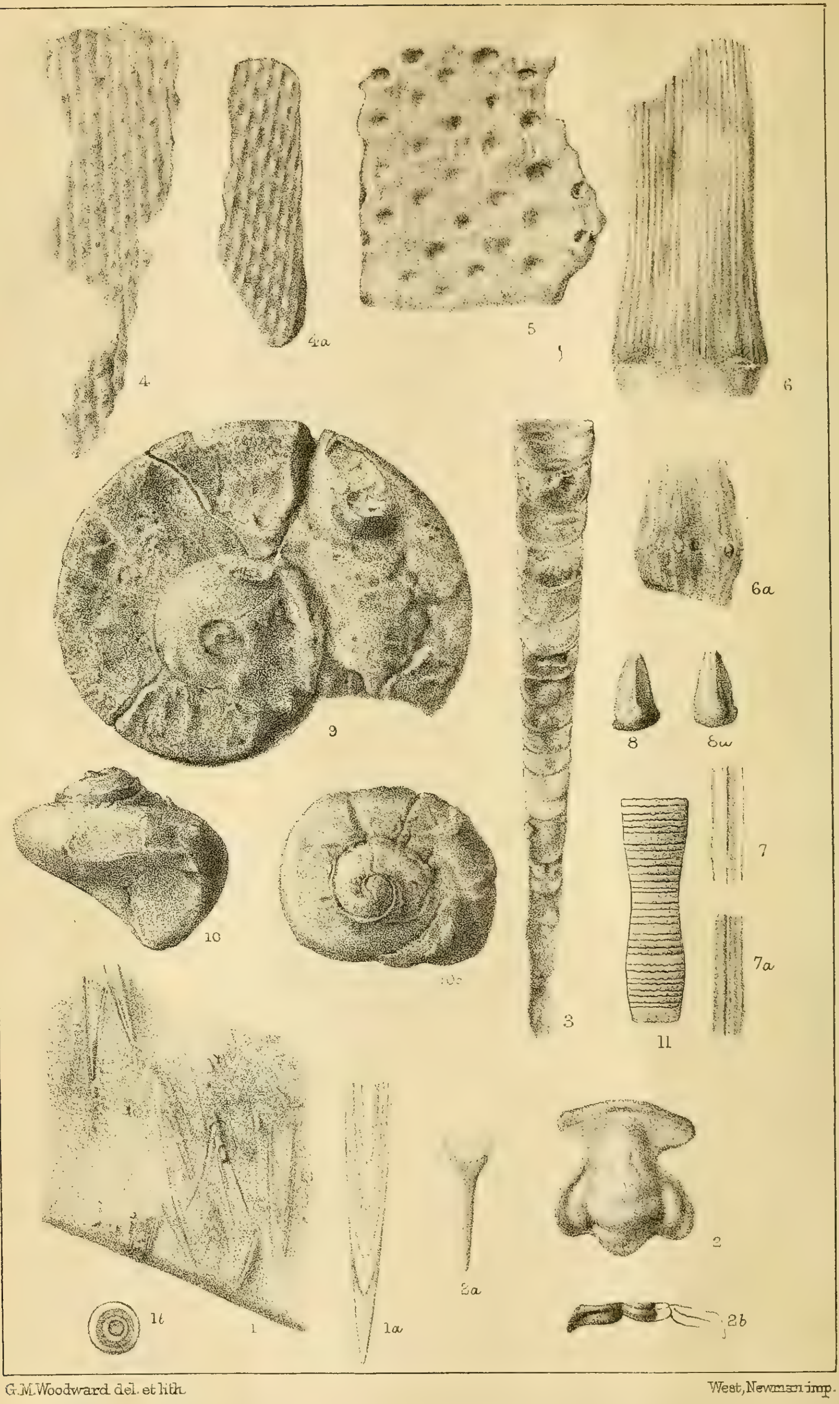
Brachiopoda. About this time he accepted the chair of Zoology at the Faculté des Sciences of Caen, with which institution he was connected for many years, and he subsequently became in addition Professor of Geology and Dean in 1861. His work had already secured for him a wide reputation both at home and abroad, and he was elected Correspondent of the Institut and Corresponding Member of the Society of Naturalists of Moscow and of the Geological Society of London. In 1863 he was appointed Secretary of the Linnean Society of Normandy, a post which he held till 1867, after which he served for a year as Corresponding Secretary.

In 1864 he published as a Doctoral Thesis his greatest stratigraphical work, "Études sur les étages Jurassiques inférieurs de la Normandie"; in the same year, the best results of his zoological researches were issued in his "Recherches sur l'organisation du Manteau chez les Brachiopodes Articulés," to the application of which to the classification of the group he frequently returned, but which he did not live to complete.

After his father's death in 1867, the younger Eudes-Deslongchamps devoted himself to the completion of the researches of the former on the Teleosaurs; his "Prodrome des Téléosauriens du Calvados" was probably his most important contribution to science, as it has formed the basis of all subsequent work on that family, and the genera *Metriorhynchus*, *Teleidosaurus*, *Pelagosaurus*, and *Steneosaurus* were either founded or first really defined in it. During the next ten years Eudes-Deslongchamps was at work on various subjects, and a list of papers on the recent and fossil mollusca of Normandy, the Brachiopods, the Cetacea, the Teleosaurians, with some botanical work, shows the wide range of his interests. He began also "Le Jura Normand," of which, however, only a few numbers were issued. A visit to the Brighton Aquarium, when that institution was at its best, inspired Eudes-Deslongchamps to agitate for the establishment of the Zoological station and laboratory at Luc-sur-Mer; he was director of this for some years, and in connection with it, did much good dredging work in the Channel, in his yacht, the "Emma."

In 1878 he resumed his connection with the Linnean Society of Normandy, and was in the same year elected to the Presidency, a post to which he was again called in 1886.

M. Eugene Eudes-Deslongchamps was perhaps one of the last of the old school of all-round naturalists; as was necessary for one who had devoted his life to the study of the whole natural history of so varied and extensive a country as Normandy, he was by turn botanist, zoologist, geologist, and archæologist; he was always ready to investigate whatever problem turned up next, and he seemed equally pleased to tackle deformed Fuchsias or Jurassic Crocodiles, Brachiopod histology or the correlation of the French Jurassics—any subject in fact that was connected with his beloved Normandy, Amongst the scientific workers of that province he can ill be spared, and the death of a naturalist of such wide and varied experience will cause a gap in the Linnean Society of Normandy that it will be difficult, if not impossible, to fill.



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

West Australian Fossils.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VII.

No. III.—MARCH, 1890.

ORIGINAL ARTICLES.

I.—Notes on the Palæontology of Western Australia.

Introductory.

A PART of the fossils described in the accompanying paper were presented to the British Museum (Natural History) by the late Mr. Edward T. Hardman, F.G.S., F.R.G.S.I., in December, 1886;[1] having been collected by him during his exploration of the Kimberley District of Western Australia, in 1883. Some additional specimens, forming a part of this collection, have been obligingly forwarded to me by Professor Edward Hull, LL.D., F.R.S., Director of the Geological Survey of Ireland; having been found, since Mr. Hardman's death, in the Survey Office, Dublin.

A collection of Carboniferous Fossils has since been received from Mr. Harry P. Woodward, F.G.S., F.R.G.S., the Government Geologist for Western Australia, which were obtained by him whilst exploring the Gascoyne River District and the Victoria District of the Irwin River. I have, moreover, been favoured with a fine slab of sandstone, full of shells of *Spirifera lata*, M'Coy (Plate VI.), from the Carboniferous formation of the Lyons River, Western Australia; collected by the Hon. John Forrest, C.M.G., and forwarded to me by the Rev. J. G. Nicolay, of Fremantle, to whom I am already indebted for the opportunity of describing the spine of *Edestus Davisii* from the Carboniferous of the same region (see Geol. Mag. 1886, Dec. III. Vol. III. pp. 1–7, Pl. I.).

The descriptions of the Brachiopoda, Mollusca, etc., have been most carefully drawn up by Mr. Arthur H. Foord, F.G.S. (late Assistant-Palæontologist to the Geological Survey of Canada); a brief note on the Plant-remains is given by Mr. R. Kidston, F.R.S.E., F.G.S. A description of the Stromatoporoids in the Collection by Prof. H. Alleyne Nicholson, M.D., F.G.S., and of the Corals and Polyzoa by Dr. George J. Hinde, F.G.S., will follow.

On behalf of my son (Mr. Harry P. Woodward) I have to express my thanks to these gentlemen for their most valuable contributions towards the description of the fossils of Western Australia, and to my friend Mr. Robert Etheridge, jun., Palæontologist to the Australian Museum, Sydney, N. S. Wales, for kindly allowing me to consult the proofs of plates and explanations thereof in MS., of his as yet unpublished work, with Mr. R. L. Jack, F.G.S. (Government Geologist), on the Fossils of Queensland, Australia, many of which bear a very close resemblance to those of Western Australia.

British Museum (Natural History), Cromwell Road, *Feb.* 15, 1890.

Henry Woodward.

[1] After the close of the Colonial Exhibition.

Description of Fossils from the Kimberley District,[1] Western Australia.

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

(PLATES IV. and V.)

I. CAMBRIAN.

PTEROPODA.

Salterella Hardmani (Etheridge, Jun., MS.), sp.nov. Plate IV. Figs. 1, 1*a*, 1*b*.

Several of the tubes of this singular genus are exposed in section on the weathered (water-worn?) surface of a piece of limestone. The tubes are of an elongate conical form, rather rapidly tapering, and straight or slightly curved, the longest about 10 lines; each contains several smaller tubes one within the other, the last of these little hollow cones being the chamber of habitation. The shell is thick, and has consequently not been crushed, two or three of the inner tubes retaining their cylindrical form, as seen in the section Fig. 1*b*.

The present species is distinguished by its slowly tapering, smooth (?), and nearly straight shell. It most nearly resembles the *Salterella pulchella* of Billings (Geol. of Vermont, 1861, vol. ii. p. 955; also Palæoz. Foss. (Billings), 1861, vol. i. p. 18), carefully described and figured by Walcott in the Bulletin of the United States Geological Survey, No. 30, 1886, p. 144, pl. xiii. figs. 3, 3*a*.

The genus *Salterella* was regarded by Billings,[2] its author, as "allied to *Serpulites*," though he considered it "sufficiently distinct therefrom to constitute a distinct genus." He subsequently (Geol. of Canada, 1863, Appendix, p. 949) placed *Salterella* with the *Pteropoda*, and was followed in this by Dana (Manual of Geology, 1863, p. 187), Barrande (Syst. Sil. de la Bohême, 1867, vol. iii. pt. i. p. 137), and Zittel (Handbuch der Palæontologie, Abth. i. Lief. ii., 1882, p. 315).

The most instructive observations that have recently been made

[1] The following is Mr. E. T. Hardman's classification of the rocks in this District:—

AQUEOUS ROCKS.

Upper Tertiary.
Carboniferous.
a. Sandstone.
b. Limestone.
Devonian.

METAMORPHIC ROCKS.

Volcanic (probably Devonian).
Plutonic (Post-Silurian).

INTRUSIVE.

See his reports on the Geology of the Kimberley District, Western Australia (Perth, W. A., 1884 and 1885; with lists of fossils, rocks, and minerals, maps and plates).

[2] Palæozoic Fossils, vol. i. 1861–65, p. 17 (1861). Mr. Billings originally described three species, viz. *S. pulchella*, *S. rugosa*, and *S. obtusa*, but the last is, according to the excellent authority, C. D. Walcott, a species of *Hyolithes*.

upon this genus are those of C. D. Walcott,[1] who remarks that "the genera *Conularia*, *Hyolithellus*, *Coleoprion*, *Coleolus*, *Hemiceras*, *Salterella*, *Pterotheca*, *Phragmotheca*, *Matthevia*, and perhaps *Palænigma*, form a group that, although representative, in a measure, of the recent *Pteropoda*, differ in other respects so much that it appears as though a division of the *Gasteropoda* equivalent to the *Pteropoda* might be consistently made to receive them." Walcott constitutes a Family—Salterellidæ—for the reception of *Salterella;* the rest of the families belonging to this Palæozoic group being Hyolithellidæ, Tentaculidæ, Conularidæ (Salterellidæ), Matthevidæ, and Pterothecidæ.

Describing the genus *Salterella*, Walcott remarks that "the shells of the species of this genus are strong and comparatively thick, much more like those of *Tentaculites* than *Serpulites*," and he adds, "I am inclined to agree with M. Barrande[2] that the relations of the genus are with *Tentaculites* and *Hyolites*"

The species of *Salterella* found in Canada are from the Middle Cambrian (Georgia Group, of Walcott[3]); the British species, *Salterella* (*Serpulites*) *Maccullochii*, Salter, is found in the Durness Limestone of Sutherlandshire, a somewhat higher horizon.

Locality.—Kimberley District.

CRUSTACEA.

PŒCILOPODA.

Olenellus ? Forresti (Etheridge, jun., sp., MS.), n.sp. Pl. IV. Figs. 2, 2*a*, 2*b*.

The specimen representing this species consists only of that part of the head which is contained within the free cheeks. The general outline of the head was probably semicircular and rather strongly convex; it was bordered by a narrow, rounded rim, only the front part of which is preserved, as seen in the figure. The glabella, which is somewhat damaged, is of an elongate conical form, widening gradually from the posterior to the anterior extremity; the front of it almost touching the marginal rim. Four pairs of glabella furrows are present, the front pair very faintly marked. The eyes are elongate, narrow, and extend in a broad arch from opposite the front or anterior glabellar lobe to the occipital furrow. The space between the eye-lobes and the glabella is slightly elevated. The occipital segment is apparently destitute of a spine.

On the weathered surface of a similar limestone rock, and from the same locality as the head just described, there is a short spine (Fig. 2*a*) probably belonging to the present species; if so, it would be the telson. In another piece of limestone similar to those containing the head and telson there is a portion of a thoracic segment (Fig. 2*b*), which agrees in form with the first two segments of an *Olenellus*; this may also belong to the present species.

[1] Second Contribution to the Studies on the Cambrian Faunas of North America, Bull. United States Geol. Surv. No. 30, 1886, pp. 131, 143.

[2] Syst. Sil. de la Bohême, 1867, vol. iii. p. 138.

[3] Second Contribution on the Cambrian Faunas of N. America, Bull. U.S. Geol. Surv. No. 30, 1886, pp. 20–24.

The conical form of the glabella of *O.? Forresti* would, at first sight, suggest its affinity with *Ptychoparia* (= Conocephalites[1]), but the shape and position of the eye-lobes contradicts any such conclusion. From *Olenellus* it differs too in its conical glabella, but as its characters appear on the whole to be nearer to that genus than to any other, I have placed it therein.

Locality.—"River south of base line;" Kimberley District.

II. DEVONIAN.

BRACHIOPODA.

SPIRIFERA? Plate V. Fig. 1.

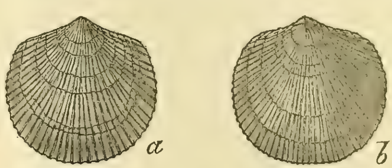
This specimen is too imperfect to warrant any conclusion as to its affinities. It is a fragment, apparently of a ventral valve, with a deep mesial sinus and prominent beak. The shell, which has lost the outer layer, is quite smooth and of a silky appearance; some fine radiating striæ are seen near the umbo.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District, in a coarse calcareous grit.[2]

ATRYPA RETICULARIS, Linnæus.

1864. *Atrypa reticularis*, Davidson, British Foss. Brach., vol. iii. part vi. p. 53, pl. x. figs. 3, 4.
1877. *Atrypa reticularis*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. ii. p. 97.
1877. *Spirigera reticularis*, M'Coy, in Rep. of Progress, Geol. Surv. of Victoria, p. 158.
1878. *Atrypa reticularis*, Etheridge, jun., Cat. Australian Fossils, p. 47.
1880. *Atrypa reticularis*, Etheridge, jun., Proceedings Royal Phys. Soc. Edinburgh, vol. v. p. 312, pl. vii. fig. 2.

This well-known and cosmopolitan species has already been found on the Australian Continent, at Yass and Kempsey, New South Wales, and Bindi, Victoria. Its discovery in the Kimberley District indicates the presence there also of rocks of Devonian age, as it is not known to occur above that horizon. The specimens, though



immature, exhibit all the external characters of this easily recognized form. One of them is figured in the accompanying Woodcut, in which *a* represents the ventral and *b* the dorsal aspect of the shell. At the same locality (Mount Pierre) there occur also two well-

[1] For the history of the generic names *Conocephalus*, *Conocoryphe*, *Ptychoparia* and *Conocephalites*, see Bull. United States Geol. Surv., No. 10, 1884; C. D. Walcott, "On the Cambrian Faunas of North America," p. 34. See also Dr. H. Woodward, on the same subject, in Quart. Journ. Geol. Soc. 1888, vol. xliv. p. 77, footnote.

[2] This fossil is in a precisely similar mineral condition to the other Brachiopods from the same locality.

known and widely distributed species of *Rhynchonella*, viz. *R. pugnus* (two varieties), and *R. cuboides*, both of which commence in the Devonian, and pass up into the Carboniferous. These species occur also at Rough Range, the significance of which fact will be recognized farther on. The other fossils included in the Devonian consist of species of *Spirifera, Orthoceras*, and *Goniatites*, all from Mount Pierre, and although they cannot be specifically determined, their occurrence in the same locality as the Rhynchonellæ, and in a similar matrix, warrants the conclusion that they belong to the same horizon.

Mr. Hardman notices the occurrence of Devonian fossils on the Margaret River, a tributary of the Fitzroy, in his second "Report on the Geology of the Kimberley District," 1885, p. 17, but he does not say to what species they belong. The following is the passage in his report to which I refer:—"The greater part of the limestone in this region is very fossiliferous. In several places in Rough Range, at Mt. Pierre, at Mt. Krauss, to the south of Hull Range, and in the rocks opposite to that hill on the south side of the Margaret, quantities of fossils of Carboniferous age were obtained, including Sponges (*Stromatopora*); Corals of several varieties; Annelids, Spirorbis, and Serpulæ; Polyzoa, Brachiopods; Lamellibranchs; Gasteropods, and Cephalopods. A few of these fossils are characteristic of the Devonian rocks, while others with which they are associated are as distinctly Carboniferous. This would denote, therefore, that these limestones belong to the Lower Carboniferous period, as it is not uncommon to find beds in the Lower Carboniferous, where fossils peculiar to both these formations intermingle to some slight extent; as, for instance, in the Lower Carboniferous rocks of Ireland, where in the county Cork true Devonian fossils are found along with the more characteristic Carboniferous fossils."

It would have been more satisfactory had Mr. Hardman given the names of the Devonian species which he alleges to have been found intermingled with Lower Carboniferous ones in the Kimberley District. This he has not done. But besides the evidence of the existence of Devonian rocks in this region supplied by such a characteristic species as *Atrypa reticularis*, there is that afforded by the Stromatoporoids from Rough Range, to be described in a forthcoming paper by Dr. H. Alleyne Nicholson, who finds that they are of Middle Devonian age.

RHYNCHONELLA PUGNUS, Martin, sp. Pl. V. Figs. 2, 2*a*.

1809. *Conchyl. Anomites*, Martin, Petrificata Derbiensia, pl. xxii. figs. 4, 5.
1864. *Rhynchonella pugnus*, Davidson, British Devonian Brach., pt. vi. p. 63, pl. xii. figs. 12–14, pl. xiii. figs. 8–10.
1876. *Rhynchonella pugnus*, ? de Koninck, Rech. sur des Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. i. p. 97.
1875. *Rhynchonella pugnus*, Etheridge, jun., Cat. Australian Fossils, p. 54.

Two variations of this species occur in the Collection. One (Fig. 2) resembles the tumid forms figured by Davidson in his British Carboniferous Brachiopoda (pl. xxii.), the other (Fig. 2*a*), the flatter and broader forms (var. *anisodonta*), figured on plate xii. fig. 12 of that author's British Devonian Brachiopoda.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District.

RHYNCHONELLA CUBOIDES, J. de C. Sowerby, sp. Pl. V. Fig. 3.

1840. *Atrypa cuboides*, J. de C. Sowerby, Trans. Geol. Soc. 2nd ser. vol. v. pt. iii. p. lvi. fig. 24.

1865. *Rhynchonella cuboides*, Davidson, British Devonian Brachiopoda, pt. vi. p. 65, pl. xiii. figs. 17–21.

This species is represented by a few very characteristic examples.

Locality.—Rough Range, opposite Hull Range, Kimberley District.

CEPHALOPODA.

ORTHOCERAS, sp. Pl. IV. Fig. 3.

The specimen presents a natural section on the weathered surface of a mass of limestone; it is a slowly tapering fragment of the septate portion of the shell 3½ inches long. The septa are moderately concave, and from 2 to 2½ lines distant from each other at the broader extremity of the specimen, where it has a diameter of 5 lines, the narrower end measuring only 1 line in diameter. Nothing of the siphuncle is seen.

It would not be possible to give any indication of the specific affinities of such an imperfect fragment.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District.

GONIATITES, sp. Plate V. Fig. 4.

Three or four broken fragments are contained in the Collection, in such a condition as to make it impossible to do more than hazard a conjecture as to their affinities. They appear to be of the type of *G. rotatorius*, de Koninck (Descrip. des Anim. Foss. de Belgique, 1844, p. 565, pl. li. figs. 1*a*, 1*b*), judging by their lenticular form, with almost closed umbilicus and close-set sutures, sharply bent forward near the periphery.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District.

GONIATITES, sp. Plate V. Fig. 5.

This specimen is seen only in a polished section. It is too obscure for specific identity.

Locality.—Mt. Pierre, near the Fitzroy River, Kimberley District.

III. CARBONIFEROUS.

(Upper or Sandstone Series of E. T. Hardman.)[1]

PLANTÆ.

Plate IV. Figs. 4, 4*a*, 5, 6, 6*a*, 7, 7*a*, 8, 8*a*.

Mr. R. Kidston, F.R.S.E., F.G.S., who has kindly examined the plant-remains, sends the following brief notes upon them:—"The specimens are all very badly preserved, but the Collection contains fragments of *Lepidodendron* (Figs. 4, 4*a*), mostly reduced to the "*Knorria* condition"[2]; *Stigmaria* (Fig. 5), rachis of ferns (?), (Figs.

[1] "Report on the Geology of the Kimberley District," 1885, p. 25.

[2] Mr. Kidston rejects *Knorria*, and says that "the plants for which it was formed are merely imperfectly preserved examples of *Lepidodendron*, and perhaps also individuals of other genera." See Cat. Palæozoic Plants in Depart. of Geol. and Palæont., British Museum (Nat. Hist.), by R. Kidston, F.G.S., 1886, pp. 167, 174.

6, 6*a*), and *Cyperites*-like leaf-fragments (Figs. 7, 7*a*), with many examples of their separated basal extremities" (Figs. 8, 8*a*).

Mr. William Carruthers, F.R.S., had suggested to Dr. Woodward that these thick triangular basal extremities of leaves, which are very abundant on some pieces of shale, might *perhaps* be broken-up fragments of bracts of cones of *Lepidostrobi*.

Localities.—All the specimens are from Yarralla Hill, near the mouth of the May River (King Sound), with the exception of the fragments of fern-rachis, which were collected at Forrest Hill.

BRACHIOPODA.

Chonetes ? sp. Plate V. Fig. 6.

The ventral valve of a young (?) individual, separated from the matrix, the external surface minutely pitted, the interior showing muscular impressions. A row of five or six perforations on each side of the beak indicate that there were spines along the hinge-line, though they are not preserved.

Locality.—"Opposite Mt. Krauss," King Leopold Ranges, near the Fitzroy River, Kimberley District.

Strophalosia Clarkei, Etheridge, sp. Pl. V. Figs. 7, 7*a*, 8.

1872. *Productus Clarkei*, Etheridge, Quart. Journ. Geol. Sec. vol. xxviii. p. 334, pl. xvii. figs. 2, 2*a*, 2*b*.
1877. *Productus Clarkei*, de Koninck, Fossiles Paléozoiques de la Nouvelles Galles-du Sud, pt. iii. p. 203, pl. x. fig. 5, pl. xi. fig. 3.
1878. *Productus Clarkei*, Etheridge, jun., Cat. Australian Foss. p. 51.
1880. *Strophalosia Clarkei*, Etheridge, jun., Proc. Roy. Phys. Soc. Edinburgh, vol. v. p. 289, pl. ix. figs. 18—21, pl. x. figs. 22—28, pl. xi. figs. 29—31, pl. xii. figs. 32, 33.

Several detached dorsal valves (Figs. 7, 7*a*) occur in the Collection, showing beautifully perfect interiors. These I have but little hesitation in identifying with the above species, which has been very amply figured and described by my friend Mr. R. Etheridge, jun., though from very poor material. In the same matrix and from the same locality there are some convex valves (Fig. 8), which may possibly be the ventrals of the present species; but the outer shell being entirely absent, I am unable to offer a decided opinion about these fossils. The inner layer of the shell remaining upon them has a silky appearance and is finely punctate.

Locality.—"South-east of Mt. Abbott," on the Fitzroy River, Kimberley District, in a yellowish ferruginous sandstone.

LAMELLIBRANCHIATA.

Aviculopecten tenuicollis, Dana, sp. Pl. V. Fig. 9.

1847. *Pecten tenuicollis*, Dana, Amer. Journ. Sci., second series, vol. iv. p. 160.
1854. *Pecten tenuicollis*, Dana, in Wilkes's Expl. Exped. 1838-42 (published 1849–1854), vol. x. Geology, p. 705, Atlas, pl. ix. fig. 7.
1878. *Aviculopecten tenuicollis*, R. Etheridge, jun., Cat. Australian Fossils, p. 67.
1889. *Aviculopecten tenuicollis*, R. Etheridge, jun., Proceed. Linnean Soc. New South Wales, 2nd series, vol. iv. pt. ii. p. 203.

"Suborbicular, 24–costate, costæ very slender, subacute, smooth. Sulci shallow, nearly flat at bottom, and having an intermediate smaller costa. Ears moderately large. Cardinal margin straight.

Length $1\frac{1}{8}$ inches; height $\frac{1}{8}$ ($1\frac{1}{8}$?) inches; distance of larger costæ at lower margin of valve, about $\frac{4}{5}$ line. Apical angle, ears excluded, slightly exceeding a right angle."

This description agrees so well with the specimen in Mr. Hardman's Collection that there is no doubt about its belonging to Dana's species. It must be remarked, however, that in his previous description of *A. tenuicollis*, Dana states that the costæ are about twenty-four. In the specimen before me they number about twenty-six. The shell is the convex valve, as was also Dana's. The latter was obtained at Harper's Hill, New South Wales, in a sandstone.

Locality.—Liverynga, Kimberley District, in a yellowish ferruginous sandstone.

GASTEROPODA.

Euomphalus ? ? Pl. IV. Fig. 9.

This specimen is far too much damaged by weathering to afford any certain indication of its affinities.

Locality. —"Opposite Mt. Krauss," King Leopold Ranges, Kimberley District.

Pleurotomaria ? ? Pl. IV. Figs. 10, 10*a*.

This fossil is in the same condition as the above; such of its characters as are preserved are well represented in the figure. It may belong to one of the subsections of *Pleurotomaria.*

Locality. —"Opposite Mt. Krauss," King Leopold Ranges, Kimberley District.

CEPHALOPODA.

GONIATITES.

Goniatites micromphalus, Morris, sp. Pl. V. Figs. 10, 10*a*.

1845. *Bellerophon micromphalus*, Morris, in Strzelecki's Physical Description of New South Wales and Van Diemen's Land, p. 288, pl. xviii. fig. 7.
1847. *Bellerophon micromphalus*, M'Coy, Ann. Mag. Nat. Hist. vol. xx. p. 308.
1849. *Bellerophon micromphalus*, Dana, Geology of Wilkes's Expl. Exped. p. 708, pl. x. fig. 6.
1877. *Goniatites micromphalus*, de Koninck, Recherches sur les Fossiles Paléozoiques de la Nouvelles-Galles du Sud (Australie), p. 339, pl. xxiv. fig. 5.
1878. *Goniatites micromphalus*, Etheridge, jun., Cat. Australian Fossils, p. 89.
1880. *Goniatites micromphalus*, Etheridge, jun., Proceed. Roy. Phys. Soc. Edinburgh, vol. v. p. 304.

This species is represented by two small and imperfect examples in a yellowish ferruginous sandstone. They are both casts, and show no trace of septation.

Locality.—Liverynga, Kimberley District.

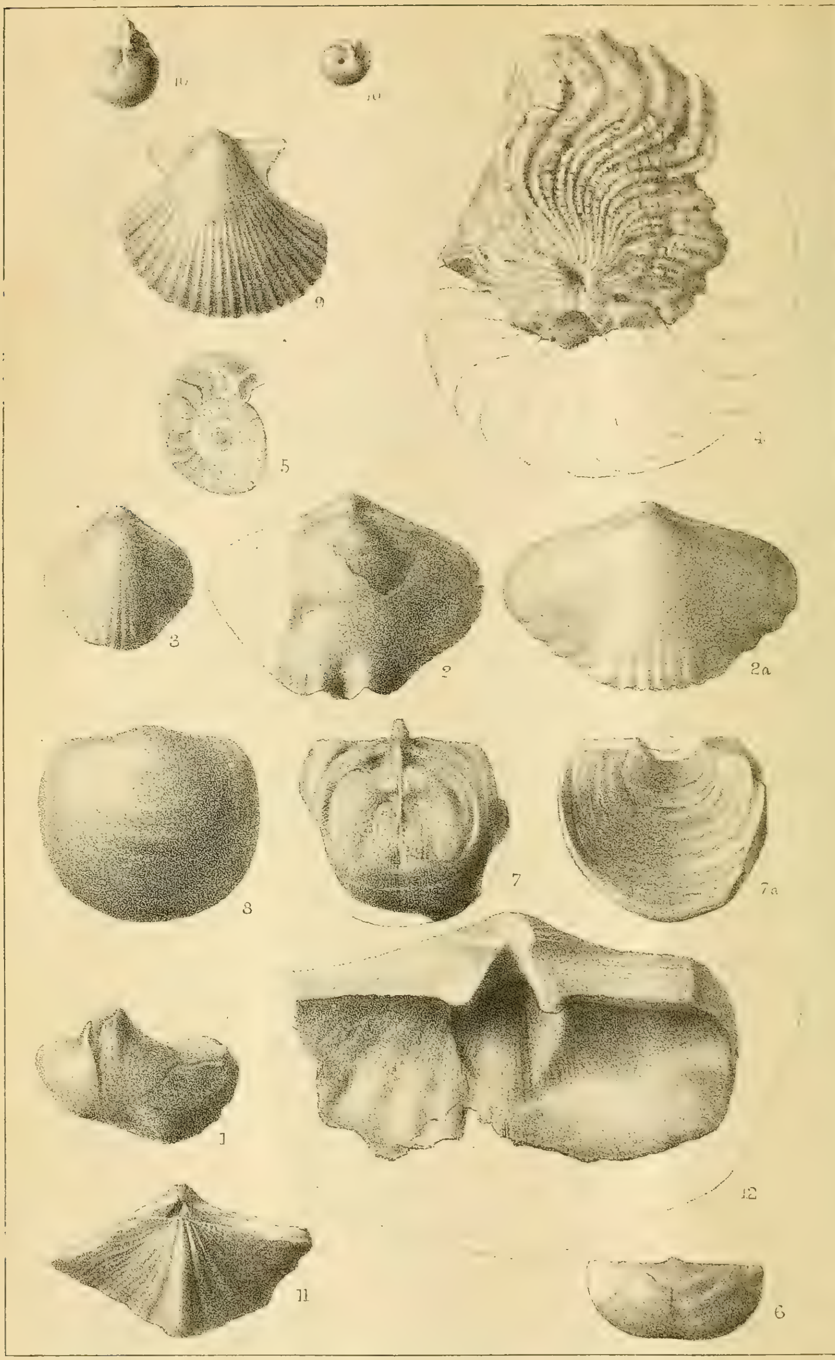
Carboniferous Fossils from the Gascoyne River and its Vicinity.[1]

ECHINODERMATA.

Plate IV. Fig. 11.

This group is represented by numerous weathered fragments of Crinoid stems, some loose, some imbedded in a limestone matrix. They have been examined by Mr. F. A. Bather, F.G.S., of the

[1] See "Notes on a Collection of Fossils and of Rock-specimens from West Australia, north of the Gascoyne River," by W. H. Hudleston, F.R.S., in the Quart. Journ. Geol. Soc. 1883, vol. xxxix. p. 582, where references to previous reports on the geology of this region may be found. The evidence afforded by the fossils of the



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

West Australian Fossils.

Geological Department of the British Museum, and he believes them to belong probably to the *Rhodocrinidæ* or *Actinocrinidæ*, but he cannot refer them to any genus.

Locality.—Gascoyne River.

BRACHIOPODA.

Spirifera Kimberleyensis, sp. nov. Plate V. Fig. 11.

The general outline of this species is transversely oval, with compressed valves and rather a long hinge-line. The ventral valve has a shallow median sinus occupied by three or four fine ribs, and bounded by two strong folds, which are most prominent in the umbonal region. About five more folds, made up of bundles of ribs, occur on each side of the last named, but they become almost obsolete in the depressed area near the hinge-line, on each side of the beaks. The beak is elevated, pointed, and but slightly incurved. The hinge-area is moderately deep, parallel, and as long as the width of the shell. The triangular fissure is tolerably large; no pseudo-deltidium is seen. The dorsal valve has a rather prominent median fold made up of five or six obscure ribs, and on each there are four or five less prominent folds, also made up of bundles of fine ribs, all of which tend to become obsolete in the flattened area near the cardinal angles. The whole of the surface of the shell is covered with very fine but distinct lines radiating from the beaks, and covering alike the folds and their interspaces; these lines can scarcely be seen without a lens. Fine concentric imbricating lamellæ are also present.

This species rather closely resembles *Spirifer Ambiensis*, Waagen ("Salt-Range" Fossils, Pal. Ind. ser. xiii. vol. i. 1887, p. 515, pl. xlviii. fig. 1), in the general character of its ornaments, especially in the bundles of finer ribs composing the folds of the shell, but the beaks in *S. Ambiensis* are more approximated than is the case in the present species, and furthermore, the fine radiating lines met with in the latter are absent in the former. *S. Kimberleyensis* is represented by a single specimen only, and it is most probably a young individual.

Locality.—Gascoyne River.

EXPLANATION OF PLATES.

PLATE IV.

Fig. 1. *Salterella Hardmani*; 1*a*, longitudinal section, 1*b*, transverse section, both enlarged.
,, 2. *Olenellus*? *Forresti*, glabella; 2*a*, telson? 2*b*, thoracic segment.
,, 3. *Orthoceras*, sp.
,, 4. *Lepidodendron*; 4*a*, "*Knorria* condition" of same.
,, 5. *Stigmaria*; surface of root showing areolæ.
,, 6, 6*a*. Rachis of ferns (?).
,, 7, 7*a*. *Cyperites*-like leaf-fragments.
,, 8, 8*a*. Basal extremities of the same (or bracts of cone?).
,, 9. *Euomphalus*? ?
,, 10, 10*a*. *Pleurotomaria*? ?
,, 11. Fragment of Crinoid stem.

Gascoyne River district (and those of a similar horizon from the Irwin River in the southern part of West Australia, and the Fitzroy River in the northern) is quite confirmatory of Mr. Hudleston's views as to the age of the Australian Carboniferous, viz. that it corresponds with the Lower, rather than the Upper Carboniferous of other countries.

PLATE V.

Fig. 1.	*Spirifera?*
,, 2, 2*a*.	*Rhynchonella pugnus*, Martin, sp.
,, 3.	*Rhynchonella cuboides*, J. de C. Sby., sp.
,, 4.	*Goniatites*, sp. near to *G. rotatorius*, de Kon. ?
,, 5.	*Goniatites*, sp. (section in limestone).
,, 6.	*Chonetes*? sp.
,, 7, 7*a*.	*Strophalosia Clarkei;* dorsal valves.
,, 8.	*Strophalosia Clarkei*?, ventral valve.
,, 9.	*Aviculopecten tenuicollis*, Dana, sp.
,, 10, 10*a*.	*Goniatites micromphalus*, Morris, sp.
,, 11.	*Spirifera Kimberleyensis*, sp. nov.
,, 12.	*Spirifera Musakheylensis*? Davidson, var. *Australis*, var. nov.

[All the figures are of natural size, except where otherwise stated.]

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

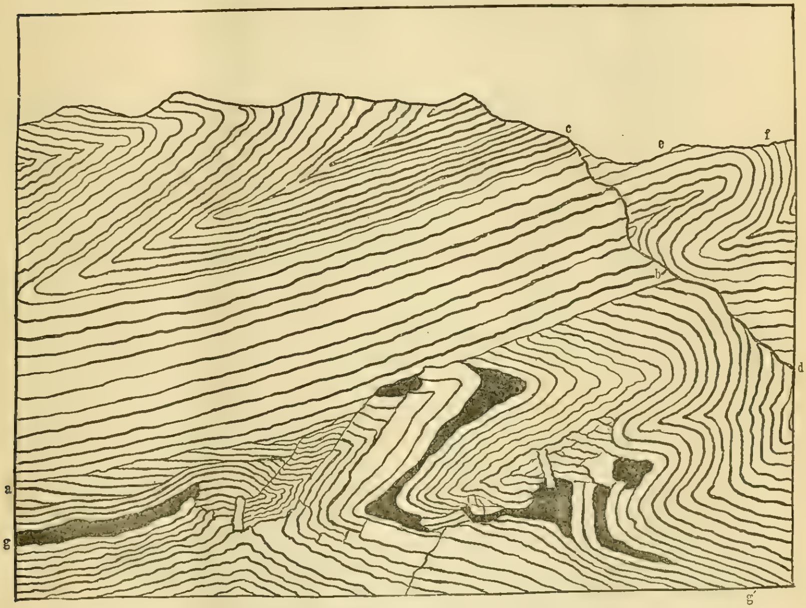
II.—Notes on the Culm-measures at Bude, North Cornwall.

By Major-General C. A. McMahon, F.G.S.

During a residence of six weeks at Bude, in the autumn of 1889, I enjoyed the opportunity of studying the Culm-measures exposed in the bold cliffs of that part of the coast of Cornwall. I know of no easily accessible place where the flexures and contortions into which strata have been thrown by earth-movements can be studied with greater advantage. Between Bude-haven and Menachurch Point, a distance of one mile as the crow flies, there are at least eleven synclinal and as many anticlinal folds, presenting a variety of flexures of considerable interest to the geological student. At one place a sharp fold in the shape of the letter ∽ placed on its side, complicated by slight rupturing, has resulted in perpendicular beds being faulted in between strata dipping at a moderate angle in a common direction; whilst, at another place, a similar flexure has led to vertical strata being jammed in between beds dipping towards each other at a low angle. In some places the contortions and convolutions are too complicated for verbal description.

Menachurch Point itself presents several features of interest. The small headland that runs out from the cliffs and constitutes the "point" coincides with a small anticlinal flexure faulted along its apex. The smooth sides of the sharply-folded beds seem to have allowed the waves to slide over them without sustaining damage from the collision; whilst the fault itself, giving an advantage to the sea, enabled it to scoop out a deep cave at the very apex of the Point. The roof and walls of the cave are, for the most part, formed by one of the folded beds, and the fault caused by the rupturing of the strata along the axis of the fold is here seen at its minimum. As one mounts the ridge forming the headland, however, and rises to a level with the top of the cliffs, the throw of the fault gradually becomes greater, and the rupture between the beds on the two sides of the fold increases until, at last, one finds almost level strata faulted against nearly vertical beds. Unless one had traced the discordance between the two sides of the flexure step by step, it would have been difficult to believe that so complicated a result had been produced in so simple a manner, and that less than a hundred yards, in point of distance, had been sufficient for its development.

The coast-line above described lies to the north of Bude. A similar state of things exists in the opposite direction. At the Haven itself the well-known feature called the "Whale's Back" is due to a sharp fold in the strata, and other contortions are to be seen in its immediate vicinity. The spot, however, likely to prove of most interest to the geologist is a little cove, three-quarters of a mile



Culm-measures, Efford Ditch, Bude, North Cornwall.

further south, called Efford Ditch. Here, high and bold cliffs are exposed which present for study a series of most complicated contortions and flexures. I spent many hours, on several occasions, attempting to draw these cliffs; but I found it impossible to give a general impression of the elaborate crumpling, faulting, and crushing, revealed by a close study of these rocks. Beds are not only doubled up and folded on themselves, but they are crushed, ruptured, and severed from each other in a way that has, in places, reduced them to the condition of a Chinese puzzle. In other places, again, where the arrangement of the beds looked tolerably simple, when viewed from a distance, a close inspection revealed some half-dozen small faults and sliding-planes, within as many yards. An extensive series of photographs would be required to convey to the mind of a person who had not studied the rocks themselves anything like an adequate impression of the severity and extent of the contortion they have undergone.

In the accompanying illustration I have attempted to give a general idea of one of the least complicated sections. Imperfect though my sketch undoubtedly is, it will, I trust, suffice to show that the rocks have sustained a pretty good squeeze. The black portion ($g\,g'$) represents a bed of dark carboniferous shale; (a, b) is evidently a fault or sliding-plane, the beds below (a, b) being crumpled in the manner represented in the sketch; (c, d) represents the jutting edge of the cliff, the portion (e, f) stands back from it at some distance, and the connection between the convolutions of the strata at (e, f) and the beds between (a, c, d) cannot be seen from the point of view from which the sketch was taken.

A few miles further to the south, at Millhook, there is another interesting cliff, known locally as the Zigzag rock. Here the rocks were first compressed into an elaborate series of sharp V-shaped flexures, and then canted over *en masse* into a vertical position, so as to favour the impression that the squeeze came from above. A photograph of those rocks has been published in the Frith Series (No. 13144). It is an interesting photograph, but the stratigraphical details are not brought out with the clearness desirable for geological study.

As the Culm-measures at Bude have incontestably suffered from intense mechanical compression, I carefully collected good samples of these rocks in the field, and brought them back with me to London for study under the microscope. I was anxious to see whether they threw any light on the problem of dynamic metamorphism, and I was therefore especially careful not only to collect samples from all the principal varieties of rocks, but to take my specimens from places where the rocks had suffered most strain. For instance, if a bed had been doubled up on itself, I took my specimen from the knee of the bend; or if the fold had resulted in the snapping of the bed, from the point of rupture, where the strain had presumably been greatest. Of the darkest and most carbonaceous beds I was unable to obtain specimens, as they have been, under the influence of pressure, smashed up into a wafery dust, possessing no cohesion. A reference to the illustration will show how these beds are squeezed thin in some places; are pinched off in others; and swell out to bulky masses in yet other places. Here, at least, if nowhere else, I hoped to find the long-sought evidence of the molecular activity and of the chemical and mineralogical changes induced by great pressure. All that I found, however, was a dust of wafers, in which you might search in vain for a fragment as thick or as large as a sixpence. Pressure had failed to produce even consolidation or induration.

Since my return to London, I have examined under the microscope thin slices taken from the hand-specimens of the other beds, and I now proceed to state the results.

Macroscopically considered, these specimens are very fine-grained rocks, and vary in colour from a pale yellowish grey through pale bluish grey to the dark colour of ordinary clay-slates. Some are distinctly arenaceous, and may be called fine-grained earthy sandstones; but they pass gradually into argillaceous shales of a slaty type. No cleavage is apparent, but some of the specimens are very distinctly laminated, and one exhibits traces of false bedding. In most of them very minute specks of silvery mica may be observed on the newly-fractured surfaces. Under the microscope these specimens are seen to be made up of quartz, felspar, and silvery mica, with occasional fragments of schorl, a few zircons, more or less decomposed felspathic or kaolinic material, magnetite, ferrite and carbon. Some slices contain calcite, and some magnesite, disseminated throughout them. There are also veins stopped with calcite. The calcite and magnesite, never exhibit twinning. It is evidently a secondary product of aqueous infiltration, and is not an original clastic component of the rock. Fragments of limestone rocks are entirely absent.

I now pass on to offer a few remarks on the principal minerals found in my specimens.

Carbon.—The dark lines of lamination which form a marked feature in some of the beds and simulate the fine banding of some crystalline schists, is mainly due to the deposition of carbon, and, in a very subordinate degree, to the presence of magnetite. The presence of carbon was verified in several ways; by the antimonate of potassa and nitric acid test; by the application of heat; and by digestion in hydrochloric and fluoric acids. Prolonged boiling in hydrochloric and in sulphuric acids failed altogether to remove the dark lines from thin slices, but the application of red heat over the Bunsen burner (applied in some cases before, and in others after, digestion in acids) effectually removed these dark bands.

The presence of carbon appears to be due to the deposit of vegetable matter along with very fine silt. Some of the specimens have obscure markings suggestive of vegetable matter, and one has a small fragment (the rest was broken off in the fracture of the hand-specimen) of what appears to have been the stem of a plant.

Though the dark lines and bands appear straight to the naked eye, they are seen, under the microscope, to owe their dark appearance to discontinuous fibres, and particles, of carbonaceous material distributed in the most irregular and uneven manner among the other materials. The carbon is not confined to the dark layers, but is distributed, though more sparsely, throughout the shales in which it occurs. In some it is very generally disseminated throughout the mass, and the rock has a uniformly dark appearance. Though the carbon for the most part is in threads, or fibres, it is perfectly opaque, and does not reveal under the microscope any trace of organic structure.

Iron.—Iron is present in the form of magnetite, ferric oxide, and apparently in combination with carbon. None of the hand-specimens attract the magnet, but splinters after fusion became magnetic. The iron was evidently deposited along with the carbon. Like the carbon, it is scattered promiscuously through the rock, but is more abundant in the dark carbonaceous bands than elsewhere.

Quartz.—Quartz is the most abundant material. It is in subangular to angular grains; these grains are rarely rounded and are never water-worn. They vary greatly in size in the same slice, ranging in the coarser-grained beds from one sixty-sixth to one eight-hundredth of an inch in their longer diameters. The orientation of such of the grains as are longer in one direction than in other directions is related in two slices only to the direction of the lamination; but in these two slices comparatively few of the grains are elongated and they are splintery fragments whose shapes are not due to pressure *in sitû.* With these exceptions the grains of quartz, in the slices examined, are oriented in all directions. The silt, of which the rocks are made up, was evidently deposited in still water, and no secondary structure has been imposed upon these rocks since their consolidation.

Very few grains exhibit strain shadows, and as the grains that do so are exceptionally few in number, this structure was, it may be presumed, set up in them before they were deposited in the Culm beds. The elongated grains do not exhibit this structure.

Liquid, and other inclusions, in the quartz, where they take the form of lines, are not oriented in any common direction; each grain has its own system, which is not related in any way to that of its neighbours.

Liquid cavities with bubbles are a common feature in the quartz grains.

Felspar.—Occasionally, but rarely, the grains of felspar contained in the slices exhibit the polysynthetic twinning of the triclinic system. In the majority of cases the felspar is much decomposed and kaolinized.

Mica.—A silvery mica is present in all the slices, and is fairly abundant in most of them. As the important question to be determined, with reference to this mineral, is whether it is an original constituent of the rock, or a secondary product formed after the Culm beds were deposited, I have been at considerable pains to try and ascertain its species. Unfortunately the mica occurs in leaves of such microscopic minuteness that it is extremely difficult to isolate any of it, and impossible, I think, to obtain a sufficient quantity for a quantitative chemical analysis.

The mica is untouched by boiling hydrochloric or sulphuric acids; and after subjecting a portion of one of my specimens, reduced to fine powder in an agate mortar, to prolonged digestion in these acids, which apparently removed everything but the quartz, mica, and carbon, I tested the residue for potash and soda and found both these alkalies present. As this experiment was vitiated by the possibility that though I could discover no felspar under the microscope in the residue left by the acids, felspathic material might nevertheless have been left behind, I set to work again, and eventually succeeded in isolating a few very minute leaves of mica. Having previously tested these leaves under the microscope, to make sure that I had got hold of the real thing, I dissolved them in hot hydrofluoric acid, and tested, by microchemical processes, with bichloride of platinum and acetate of uranium, and again obtained unmistakable evidence of the presence of both potash and soda. I also found some lime and magnesia. Iron was absent.

These results show, I think, that the mica must either be muscovite, paragonite (classed by Tschermak as a variety of muscovite),[1] or margarodite; but in the absence of a quantitative analysis, the chemical evidence does not enable us to say positively which of these it is. Margarodite may, however, be eliminated from consideration, as, according to Brush, this mineral is decomposed by sulphuric acid, whereas the mica of the rocks under consideration certainly is not. There remain muscovite and paragonite: both contain potash and soda, though in different relative proportions; but whilst muscovite contains up to 2 per cent. of magnesia and 0·5 of lime, these substances, though occasionally present in small quantities, are usually absent from paragonite.

But though the chemical evidence does not lead to any very definite result, the microscopic evidence gives a clear answer to the question raised. The mica presents the appearance of having settled down with the sand and mud when these beds were originally deposited. It is not arranged in continuous straight lines, or in planes in which mica is abnormally developed, but is scattered promiscuously throughout the rock. In many slices it is oriented in all directions, and even in those which exhibit a laminated structure, the leaves of mica are frequently oriented at variable and considerable angles to the lamination. The leaves of mica are often bent and occasionally ruptured, just as mica would be bent and ruptured if it were deposited in water along with grains of sand, and subsequently compacted by mechanical pressure between angular and subangular grains of such hard minerals as quartz and felspar. In this respect the Bude beds have a very close resemblance to the Tertiary Sivaliks of the outer Himalayas. In these mica was deposited along with grains of quartz, felspar, slate, and limestone, and the rocks being of comparatively coarse grain, the way in which the leaves were, in the process of consolidation, bent, crumpled, and ruptured, between the grains of quartz, felspar, etc., form an interesting study.

Schorl and zircon.—The schorl is generally in irregular-shaped grains such as one meets with in granites, but I have observed needles in some quartz grains that may be this mineral. The zircon is in regular crystals such as commonly occur in crystalline rocks.

Secondary minerals.—Exclusive of vein material, alluded to below, the only secondary substances I have observed are magnetite, ferric oxide, opalescent quartz, carbonate of lime, and magnesite; both of which latter are in a granular condition.

Veins.—Old cracks in the rocks are stopped in some cases with quartz, and in other cases with carbonate of lime. One slice contains three cracks, which present some features of interest. The one first formed in point of time is a thin one stopped with crystalline quartz. This was subsequently cut across by a wider crack,

[1] Third Appendix to Fifth Edition of Dana's Mineralogy, p. 77.

also filled with crystalline quartz, which is traversed by a third crack—the youngest in order of birth—stopped with carbonate of lime. The quartz in these cracks is full of liquid cavities with moving bubbles, but these inclusions do not orient in lines having a common direction. The feature to which I desire to call especial attention is that the second vein, in order of birth, has its quartz split up into narrow ribbon-shaped crystals, approximately at right angles to the direction of its length, but the older vein is totally devoid of this structure, and the carbonate of lime that stops the youngest vein exhibits no twinning, The twinning of calcite is commonly held to be the result of pressure, and I think the division of the second vein throughout its length into stripy quartz crystals, narrow as compared with their length, must be due to strain. We have then three cracks formed and filled with crystalline materials at different periods. No. 2 cuts the first formed at an average angle of 35°, and the last formed vein cuts No. 2 at an angle of 16°. The mineral stopping No. 2 exhibits evidence of strain, whilst the minerals stopping Nos. 1 and 3 are devoid of any such evidence. These facts seem to me to indicate that the strain which has left its marks on No. 2 could not have been applied subsequent to the crystallization of the mineral contents of all three veins, for had it been, there seems no reason why Nos. 1 and 3 should not have exhibited the marks of strain as well as No. 2. The facts seem to lead naturally to the inference that the strain which has left its marks on No. 2 was applied at a critical stage in its history when the quartz was in a condition to yield to that strain; and as this strain was applied after the quartz in No. 1 had passed that critical stage, and had hardened into its present condition, it was unaffected by it.

The evidence afforded by these veins teaches us that we should hesitate before we accept the evidence of strain exhibited by individual minerals, or groups of minerals, as proof that this strain was applied after the consolidation of the whole rock. This is an important point which is sometimes lost sight of.

Conclusion.—The Culm series, as seen at Bude, appear to have been deposited in tranquil water undisturbed by strong currents. Though there is occasional evidence of current, this is exceptional; and the materials of which the rocks are built up seem, on the whole, to have settled down quietly without much sorting, and without the longer axes of the grains being arranged in a common direction, which would have been the case had there been a sensible current. The layers of carbonaceous matter of organic origin point to the same conclusion.

Mr. Medlicott, in his Memoir on the Sub-Himalayan Rocks of N.W. India,[1] quotes the following remarks of a colleague, Dr. Kane, on the fossil leaves from the Tertiary rocks of the Sabathu group collected by the author of the memoir:—"A number of well-preserved plant-remains were found in the rocks of the Kasauli range. They are probably of Middle Tertiary age, and are

[1] Memoirs G.S.I. vol. iii. p. 97.

imbedded in an indurated shaly clay, bluish and slightly micaceous. It is evident from the regularity with which these remains are disposed—the leaves being in no case crumpled, or distorted, as well as from the fine texture of the rock in which they occur—that they have been deposited from water either perfectly still, or only slightly in motion."

I have several good samples of the Sub-Himalayan leaf-beds above alluded to, and have studied slices of them under the microscope. In point of *structure*, and in the character and arrangement of their component grains, and leaves of mica, they are indistinguishable from many of the Bude beds. If the one is composed of original materials deposited in still water, this statement must be equally true of the other.

This conclusion regarding the Bude rocks arrived at on purely microscopical evidence appears to agree well with the state of things described by Mr. A. J. Jukes-Browne, F.G.S., in his Building of the British Isles. After quoting from Prof. Green an account of the process of sedimentation that probably went on during the deposition of the Millstone Grit and Coal-measures, which is too long to give here, he adds in a footnote: "It would be better described as an immense delta or fenland, including many large lagoons and wide channels, surrounded by swamps which were never much above the level of the sea."[1]

So much for their manner of deposition. As regards their *origin*, the microscopical evidence favours the view that the materials of which the Bude rocks are composed were derived from the waste of a crystalline area, for they are made up of fragments of quartz, felspar, and mica, with some schorl and zircon crystals—all characteristic of granitoid rocks—together with some crystalline fragments of more schistose character. It is also material to note that they do not contain a single grain of such rocks as slate, or limestone.

I see no reason to suppose that the materials were derived from older sedimentary rocks, or that they travelled any great distance before they found their present resting-place. The absence of water-worn granules and the want of variety in the assortment of minerals are opposed to both these suppositions. The sand of rivers fed by extended catchment areas, or that flow for long distances over several geological systems, is usually as rich in specimens as a well-stocked mineralogical museum.

The specific gravity of slate and limestone does not differ very greatly from that of quartz and felspar, as will be seen from the following table:—

Clay-State (B. Von Cotta) ...	Sp. G.	2·5	—	2·8
Limestone (*ib.*)	,,	2·6	—	2·8
Quartz (J. D. Dana)	,,	2·4	—	2·8
Felspar (*ib.*)		2·56	—	2·75

If then the catchment area that supplied the Culm-beds at Bude contained exposures of slate or limestone, I think it is as certain as anything of the kind can be, that the Bude beds would have con-

[1] The Building of the British Isles, p. 90, footnote.

tained fragments of such rocks. The sand of the existing Panjab rivers, and the Sivalik beds, the product of Panjab rivers in the Tertiary period, abound in fragments of slate and limestone.

As a rule, I presume, heavy minerals are carried down by the main stream of a river, and the lighter ones are floated off over its banks to flood the country on either side of it; but this explanation can hardly be applied to the Bude rocks, as it would fail to account for the absence of such rocks as slate and limestone, on the one hand, or the presence of such minerals as schorl (sp. g. 3—3·24) and zircon (sp. g. 4·4—4·7) on the other. If schorl and zircon could have been floated to Bude, why not hornblende and other minerals?

Mr. A. W. Stokes, F.C.S., F.I.C., was good enough to make an analysis of one of the Bude samples for me, which I give below as No. I. The specimen was a slaty-looking shale.

	I.	II.	III.
Silica	73·20	... 73·70	... 74·54
Alumina	11·20	... 14·44	... 14·86
Oxide of Iron	8·40	... 1·92	... 2·76
Lime	—	... 1·08	... ·29
Magnesia	1·44	... trace	... trace
Potash	trace	... 4·43	... 3·73
Soda, with traces of potash, sulphates, and carbon.	5·26	Soda 4·21	... 3·49
Phosphoric acid. ...	trace	... trace	... —
Water	·50*	... ·61	... ·87
	100·00	100·39	100·54

* Obtained by heating to 120° C. for four hours.

I have for the purposes of comparison given under II. and III. the analyses of two British granites made by Mr. J. A. Phillips, quoted by Mr. J. J. Harris Teall in his British Petrography, pp. 311, 314. I have selected these two because they come close to the analyses of the Bude rock in the per-centage of silica. II. and III. contain only a trace of magnesia, but in other analyses of granites made by Mr. J. A. Phillips this constituent rises to nearly 2 per cent.

An examination of the above analysis of the Bude shale bears out, I think, the result of the microscopic investigation. It seems to me to support the view that the silt deposited by the Bude waters was made up of granitic materials supplemented on the spot by the products of organic life, carbon, and iron; the carbon being derived by organic processes from the air, and the iron from the water.

One more point remains for consideration. Beyond all question the Bude rocks have, since their consolidation, been subjected to great lateral pressure, contortion, and crushing. On the other hand, it is equally certain that they could not by any stretch of the imagination be called metamorphic, or metamorphosed, rocks. But if dynamic force is capable of producing the metamorphic changes claimed for it by the exponents of dynamic metamorphism, how is it that the Bude beds are not metamorphosed? This is, I think, a pertinent question directly raised by the Bude beds, and one that is worth some serious consideration.

In offering a few concluding remarks on this subject, I propose to leave out of consideration cases in which shearing is the alleged cause of metamorphism. Shearing would open up a very wide branch of inquiry, and as the Bude rocks do not exhibit cleavage, or foliation, or mineralogical changes that could be attributed to shearing, it will simplify matters to eliminate this branch of dynamic metamorphism from the discussion.

There remains the question whether pressure, apart from shearing, is capable of setting up molecular activity of such a character that the chemical constituents of a rock rearrange themselves in the manner implied by the use of the term metamorphism?

In this connection I do not think I can do better than quote from the highly interesting opening address of the President of Section G at the last meeting of the British Association.[1] After alluding to the mobility of the atoms or molecules of solid bodies, and after giving an account of Spring's experiments, Mr. Anderson goes on to say: "The same movements and changes have taken place and are still going on in Nature's laboratory. During the countless ages with which geology deals, and under the enormous pressures of superincumbent masses, stratified sedimentary rocks become crystallized, and assume the appearance of rocks of igneous origin, and not only so, but rocks of whatever origin, crushed and ground to pieces by irresistible geological disturbances, reconstruct themselves into new forms by virtue of the still more irresistible and constant action of molecular forces and movements."

The student must not allow his mind to be mystified, or carried away from the real point at issue, by such phrases as "the countless ages with which geology deals." The Alps and the Himalayas had their birth in Tertiary times, and if the rampant metamorphism of Himalayan rocks is to be referred to the dynamic throes of mountain-making, those throes were, geologically speaking, of yesterday's date, and we cannot indent on "the countless ages with which geology deals" to impart a poetic and occult glamour to the prosaic details of dynamic force exerted so recently as the Middle Tertiary period.

One other remark I would make, and that is, that laboratory experiments, like Spring's, however instructive and valuable, hardly run on all fours with the conditions that exist in nature. Mr. Anderson, for instance, with his eye on Prof. Spring's pestle and mortar, speaks of rocks, like Spring's powders, being "crushed and ground to pieces by irresistible geological disturbances" before they began to "reconstruct themselves into new forms by the still more irresistible action of molecular forces and movements." I am not sure whether Mr. Anderson considers this grinding to powder an essential part of the process in every case; if he does not, Spring's experiments may be put out of court at once; if he does, this assumption, it seems to me, is likely to prove fatal to the theory. In the Himalayas we have to deal with outcrops of foliated granites, not to speak of other crystalline rocks, ten miles thick and hundreds of miles long, and can any one, I would ask, believe that these

[1] Nature, September 19th, 1889, p. 510.

beds were ground down to a powder before they were re-consolidated into crystalline schists? The crushing of rocks to powder must surely have been a local phenomenon very limited in its extent.

One hears much of Spring's experiments, but I have seen no reference to those of Hallock,[1] who subjected layers of antimony, beeswax, parafine, ground bismuth, a second layer of parafine and lead, with silver pieces stuck on the wax and parafine, to the pressure of 6000 atmospheres. The materials came out unchanged, unmelted and unmixed. The silver coins left their marks on the steel sides of the instrument employed, but they did not sink through the wax or parafine, which they would have done had the wax or parafine liquefied. Mr. Hallock drew the conclusion from his experiments that "to me they seem to establish that pressure alone cannot truly liquefy a solid, *i.e.* diminish its rigidity, consequently we should scarcely expect chemical or mineralogical changes to be produced by pressure alone."

In the Bude rock we have laid bare for our study, not a laboratory experiment made under artificial conditions, but the operations of Nature herself. The rocks are contorted, crushed, ruptured, and compressed; they have undoubtedly been subjected to very great pressure; how is it that they are not metamorphosed if pressure alone is competent to produce metamorphism? It cannot be said that they have not been subjected to enormous pressure. It cannot be said that they have not been sufficiently mellowed by the lapse of those "countless ages with which geology deals," for the disturbances that crumpled the Culm-measures would seem to have been of considerably greater antiquity than those that gave birth to the Himalayas. How are we to estimate the intensity of a squeeze except by the crushing and crumpling produced by the squeeze? To say that the rocks would have been metamorphosed had the squeeze been sufficient in intensity and duration is to beg the whole question.

That metamorphic rocks are often highly contorted rocks may be freely admitted, but it does not follow from this fact that pressure and metamorphism are related to each other as cause and effect. Indeed, though contortion and metamorphism are sometimes found to coexist in the same rocks, they are sometimes found apart. The Bude rocks show that highly contorted rocks are sometimes devoid of metamorphism, and I can point to the converse case where highly metamorphosed rocks are devoid of contortion. I can point to a considerable area in the N.W. Himalayas in which metamorphism is at its maximum, but where the beds give little or no evidence of disturbance.

In my first paper on Himalayan Geology I described my passage over the Rupin[2] and some other passes. The beds traversed were mica schists, siliceous schists, and gneiss. For a distance of 40 miles, measured in straight lines on the map, and up and down over strata exceeding 10,000 feet in thickness, the ever-recurring

[1] American Journal of Science, 1887, p. 277.
[2] Elevation 15,480 feet.

entry is "dip low," "dip flat";[1] and it is only at the commencement of this traverse that I noted "some crushing and contortion near Nara"; and at its termination at Roru,[2] that the dip, which for the last few miles had been "very low N.E., suddenly rose to 50° beyond Mandári, and then became perpendicular." Other traverses in that neighbourhood might be quoted; they would extend the area without modifying the result.

If then we find extreme metamorphism in cases where there is no contortion, and great contortion where there is no metamorphism, are we not justified in seriously doubting whether pressure alone, without some other concurrent cause, can produce metamorphism?

III.—Notes on the Geology of South Bedfordshire.

By James Saunders.

THE District included under the term "South Bedfordshire" is that which lies between the escarpment of the Lower Greensand and the extreme southern limit of the county. Within this area the portion that has been most closely examined is that through which the Midland Railway passes, every excavation of which has been visited, in many cases frequently, both during the construction of the line, and also subsequently. A section drawn approximately north-west and south-east through the district in question would cover about fifteen miles of country, and the principal strata underlying it are as follows:—

Oxford Clay and Coralline Oolite, near Ampthill.
Lower Greensand, Flitwick.
Gault, near Harlington.
Chalk Marl, Chalton cutting.
Totternhoe Stone, ,, ,,
Lower Chalk, ,, ,,
Belemnitella plena zone (Lower Chalk) between Leagrave and Luton.
Melbourn Rock (Middle Chalk) ,, ,, ,,
Rhynchonella Cuvieri zone (Middle Chalk) ,, ,, ,,
Middle Chalk, in massive blocks. Cutting S.E. of Luton.
Chalk Rock (top bed of Middle Chalk). Between Luton and Chiltern Green.
Upper Chalk, with numerous flints. ,, ,, ,,

Taking these beds in the order in which they are mentioned, which, although it is that of the sequence of formation, is the reverse of that of superposition, it is proposed in the following notes to give a brief account of their leading features, and also of the fossils that have been found in them.

At Ampthill the excavations for the approaches to the tunnel expose the Oxford Clay and Coralline Oolite. When first opened, the lines of bedding could be distinctly seen, but subsequent weathering has obscured many interesting features. The cuttings exhibit a series of beds of clay, brown at the top, and containing many small crystals of selenite, whilst lower down the beds are dark blue, and with them are intercalated seams of hard grey limestone, from a foot to eighteen inches in thickness. The lower beds have fewer selenite crystals in them, but these are more regular in form and beautiful in appearance. One specimen obtained from the

[1] Records G.S.I. vol. x. p. 219. [2] Elevation 5250.

tunnel measured six inches in its longest diameter. The most frequent fossils are *Ostrea*, *Belemnites*, and *Ammonites*. Occasionally the bones of Ichthyosauri and Plesiosauri are found, some of which must have been from animals of enormous size. My notes say that "a single vertebra of *Plesiosaurus* taken from the tunnel weighed ten pounds." This is from information obtained from the workmen during the progress of the works, when the line was being constructed.

Near the village of Flitwick are two cuttings in the Lower Greensand, besides several sand-pits in the immediate vicinity. In most of the sections, especially the one near the railway-station, the dip of the beds is well exhibited. They consist of yellow and nearly white sands, alternating with dark bands of ironstone. This series of beds extends across the county beyond Sandy in a north-easterly direction, and near Leighton Buzzard towards the south-west. At Silsoe, about four miles east from Flitwick, is an extensive pit, in which is exposed a hard compact dark brown sandstone. This furnishes a building material which has been used in the locality for a long period, and is apparently that from which the present Silsoe Church has been constructed. So extensive is the sand-pit that much of it has been turned into a plantation, in the shade of which, on the ancient facings of the stone, numerous mosses and ferns luxuriate.

The cutting south-east from Westoning passes through a bed of dark heavy clay, which is apparently Gault. It exposes a continuous band of coprolitic nodules, which averages about a foot in thickness. This layer passes through about one-third of the northern portion of the cutting, and is parallel with the general dip of the beds of the locality. The fossils obtained when the section was first examined were *Lamna*, *Belemnites*, *Terebratula*, and *Parasmilia*.

Near the village of Chalton, in the parish of Toddington, the hills forming the Lower Chalk escarpment are pierced by an extensive cutting more than a mile in length. In addition to the exposure of beds in this excavation, there are also some large lime-works near the north-east end, close by the railway, in which are sections on a higher level than those of the adjoining line. Until the present year (1889) these have been for several seasons in active operation, and a considerable section of chalk is exposed. Consequent upon the abandonment of the works, a considerable talus has accumulated at the base of the deepest rock-face, which obscures some portion of the section that was formerly visible. In other parts of the workings the vegetable soil has been taken off by the workmen, leaving exposed tabular masses of Totternhoe Stone, which have been weathered into moderately thin plates, presenting a most desirable condition for seeking the contained fossils. These are both characteristic and interesting, and a diligent search will soon be rewarded by at least several forms of Brachiopoda. At the end of this paper is a list of the fossils both from this locality, and the other principal sections. A few of the most noteworthy obtained from the adjoining cutting, deserve, however, a passing notice.

Mr. Jukes-Browne, F.G.S., who has been most indefatigable in naming the fossils, and otherwise assisting with his extensive knowledge of their distribution, has in correspondence with me made certain comments on some of the specimens submitted to him, which will probably be of general interest. In a letter dated January 30th, 1887, he says: "There are several interesting specimens, among them the Turrilite being especially so, as it belongs to a species which has only yet been found in the south of England, *Turrilites Mantelli*." In another letter received shortly before, occurs the following extract: "The larger specimen (Belemnite) from Chalton is, I consider, a new species, and I am particularly pleased to have seen your specimen, because all I have seen before from the Totternhoe Stone were smaller, so that I was not sure whether it was a new species, or the young of *Belemnitella plena*. The fact of yours being larger, and still retaining the character of being the same width from top to centre, confirms my notion of its being an undescribed species.[1] Of the Brachiopoda from this cutting some prevalent forms are *Terebratula semiglobosa* and *Rhynchonella Martini*."

The same bed has also furnished two interesting specimens of a rare Crustacean, *Palæga Carteri*, H. Woodward, one of which was from the lower portion of the Chalk Marl, where it is bluish-grey, and the other from the higher part, which is distinguished as the Totternhoe Stone. The latter specimen possesses the caudal appendages by which Dr. H. Woodward was enabled to determine the affinities of the species, and which that gentleman has described and figured in the Geol. Mag. 1870. It was hoped that during the progress of the excavations now being made in this cutting for the widening of the Midland line, additional examples of this interesting species would be brought to light, but at present these hopes are unrealized.

The following sections were observed at Chalton, Aug. 25th, 1889.

North-east end of pit of the Lime Works.

Soil	1 foot.
Lower Chalk	about 20 feet

South-west end of pit of the Lime Works.

Totternhoe Stone, above which the soil had been removed	2 feet
Clayey Chalk	½ foot
Chalk Marl	14 feet

Section in the cutting a few rods further south, close to the bridge.

Earthy Clay	3 feet
Chalk	5 ,,
Totternhoe Stone	2 ,,
Chalk Marl	about 33 ,,
Total at this the deepest part of the cutting,	about 43 ,,

The Totternhoe Stone is a marked feature at the northern portion

[1] Under date Jan. 21, 1890, Mr. Jukes-Browne expresses the opinion that the *Belemnite* is probably that figured by Sowerby (Min. Conch. pl. 600) under the name of *Belemnites lanceolatus*.

of this cutting. It comes to the surface a little north of the bridge in the immediate vicinity of the lime-works, and passes downwards with a gentle slope till it disappears southward at the level of the line. In another section on the same horizon exposed on the London and North-Western Railway between Dunstable and Totternhoe Mr. Whitaker has distinguished two beds of this stone. At the present time, however, there is only one that is easily visible, standing out in relief from the softer beds, the other being obscured by the detritus resulting from the weathering of the section. The presence of this stone is somewhat of a grievance at the lime-works adjoining this cutting, as it is utterly useless for lime. From its arenaceous composition it crumbles into powder during the burning, when by accident any of it is allowed to pass into the kilns. In some extensive works further westward, just at the base of the Totternhoe Knoll, there is a fine section of the Grey Chalk which overlies the Totternhoe Stone, but during the present year the stone itself can only be seen in very small sections. A few years since it was well exposed in the deepest part of the works, when it presented a surface of three or four feet in thickness of a massive dark grey sandy limestone; at least that was the depth then exposed. It is probable that during the next season a considerable quantity of it will be excavated, as there are extensive orders on hand for the Totternhoe Stone, which is required both in the restoration of a mansion in Scotland belonging to the Marquis of Bute, and also for St. Albans Abbey. It need hardly be said that this stone has been largely used in the construction of the churches of this district, of which examples are furnished not only by St. Albans Abbey, but also by Dunstable and Luton Churches. In the latter, nearly the whole of the tower is built of alternate cubes of Totternhoe Stone, and chalk-flints set in mortar, in this way utilizing the materials that were most easily obtainable. This was a matter of great importance in times when the only means of overland transport was by bad roads, or mere tracks.

Reverting to the sections that are exposed by the excavations made for the Midland Railway, there occurs a short distance from Leagrave towards Luton, a long and rather shallow cutting which exposes a series of beds in the Middle Chalk. Close by the railway, about a mile from Leagrave, and one and a half from Luton, some lime-works have been opened, where an interesting section is exposed, which descends below the level of the deepest exposure in the adjoining cutting. In the Quarterly Journal of the Geological Society for May, 1886, Mr. Jukes-Browne gives a detailed account of the section in the lime-works, from which it appears that beneath four feet of soil and thin-bedded chalk, there are seven feet of Melbourne Rock, and five feet of Chalk and shaly marl composing the *Belemnitella plena* zone, resting on fifteen feet of blocky Lower Chalk. Owing to the cessation of operations at this place, only a small part of the lowest bed is now visible, but the whole of the details of the other portions of the section may still be easily distinguished. The fossils recently obtained from these works are enumerated in the list at the end of this paper, the most abundant form being *Ostrea vesicularis*, var. *Baylei.*

On the side of Hart Hill overlooking Luton are some of those terraces or lynchets so characteristic of the Chalk Hills. Other examples exist between Luton and Dunstable, near Chalk Farm, also above the Old Bedford Road, near Stopsley; and again near Chalton on the Lower Chalk escarpment, of which a figure is given in the Memoirs of the Geol. Surv. vol. iv. pt. i. p. 366, also in the curious valley at the base of Ravensbury Castle, on the border of Beds and Herts. This hollow, in the very heart of the hills, has sides as sharply outlined as though excavated by human agency, and in its extent describes nearly a semicircle. Commencing on a south-eastern aspect, it continues in that direction for a short distance, then turns sharply towards the east, gradually curving in a northern direction, till it eventually opens on the general trend of the escarpment at the village of Hexton, where several springs take their rise.

Between Luton and Chiltern Green there are several interesting exposures of beds in the Middle and Upper Chalk, along the courses of the G.N.R. and Midland lines, the most extensive of which are those of the latter railway. The first excavation of any extent is about a mile south-east from Luton; it contains many flints, breaks up into massive blocks, and in the opinion of Mr. Jukes-Browne is to be classified as Middle Chalk. Proceeding in the same direction, the cutting opposite to Luton Hoo Park presents an excellent section of the Chalk Rock, which is usually regarded as the line of demarcation between the Upper and Middle Chalk. The beds exposed in this cutting are, in descending order,

	Feet.
Chalk with flints	6 to 8
Upper thin seam of Chalk Rock, about	$\frac{3}{4}$
Chalk, intermediate to two seams of Chalk Rock ...	6 to 8
Lower seam of Chalk Rock	3 or 4
Middle Chalk, with flints at top	10 to 12

The Chalk Rock is excessively hard, so that, although crowded with fossils, it is difficult to develope them satisfactorily. In some places it is so indurated that it rings almost like flint when struck with a hammer. It is not, however, uniformly compact, for in other places it is easily pulverized. The prevailing colour is grey, sometimes merging into a creamy white, and it contains many green-coated nodules. There are two beds often faulted lying approximately parallel to each other, at a short distance apart.

The Chalk Rock also occurs on the opposite side of the valley at Luton, under the London Road hill. It was customary, some 40 or 50 years ago, when lime-works were in operation at this place, for the workmen to drive headings with a rather steep incline into the hill, until the Chalk Rock was reached, when they could excavate considerable chambers beneath it, as it formed an excellent roof for their workings. These tunnels were sometimes driven twenty yards under the hill on the western side of the London Road, and indications of the works may still be distinguished.

The Chalk Rock in the cutting previously referred to is one of the richest stations for fossils in this district. The Brachiopods and Echinoderms are always well preserved, but the more delicate shells of the univalves have perished almost without exception, leaving excellent casts of their external ornamentation, and a spiral mould of their interior. The Cephalopoda have also experienced a similar decay, and when broken show the divisions of their chambers, sometimes exhibiting also a cast of the siphuncle. The general facies of the fossils indicates a closer affinity with those of the Middle and Lower Chalk, than with those of the Upper Chalk.

Overlying the Chalk Rock, and forming the upper portion of the adjacent hills on each side of the valley, occurs the Upper Chalk, with numerous flints. It is white, friable, rather soft, and traversed by many joints, by which it separates into blocks of various sizes. Flint is present both as nodules, and in thin seams. Occasionally there are thin layers of a grey clay somewhat resembling fullers' earth, which indicate the lines of bedding.

Overlying the Chalk in many places may be observed drift sands and gravels, and Boulder-clay. The drift is often exposed in digging in the Luton Valley, and is to be seen also in the Leagrave and Biscot pits. It contains many rolled fragments of *Belemnites*, and both *Gryphœa dilatata* and *incurva.* A fine specimen of the latter was obtained from the gravel at Hart Hill, Luton, the edges being well preserved, it having been but little exposed to attrition.

The fossils proper to the age in which the drift was deposited that have been found near Luton are the scapula of a deer from the ballast pit that formerly existed near the first mile-stone north of Luton, and the tibia of a deer from the excavation for a cellar at the bank of Messrs. Sharples & Co., which was found lying about ten feet from the surface.

At the gravel pit near Biscot, Mr. Latchmore found a fine antler of a deer about twenty-two inches in length, also the core of the horn of *Bos.*

The Boulder-clay exists as a surface deposit in many places round Luton, as, for example, London Road Hill, and the People's Park. Specimens of many of the typical boulders, both sandstone and pudding-stone, may be seen in the immediate neighbourhood of Luton.

In connection with the surface deposits of South Bedfordshire, the supposed discovery of gold at Pulloxhill deserves a brief notice. The following particulars have been furnished by Mr. C. Crouch, of Kitchin End near Pulloxhill, who has courteously placed them at my disposal. Under date November 28th, 1889, Mr. Crouch writes:—"The report of gold at Pulloxhill is due to a bed of sand which may be traced from Pulloxhill Church in a north-easterly direction to the Thrift Wood. This bed of sand contains an interesting agglomerate. A specimen of this was submitted last summer by Mr. Cameron to Mr. Rudler, of the Jermyn Street Museum. He writes as follows: 'The rock containing the brilliant gold-suggesting flashes is a highly micaceous sandstone, mainly consisting of crystalline quartz with abundant mica. Crushed in a mortar, and the powder examined under a microscope, the quartz is much iron-stained, giving the material a yellow-brownish tint, which conspires with the glistering bronze colour of the mica to suggest a gold-bearing material.' The history of the various attempts to find gold is confused; but about forty years ago I believe a quantity of the rock was dug and taken away to be tested, apparently without result. This, however, was not the first trial. A grass field, about 25 chains north-east from the Church, has long been called 'Gold Close,' and in or near the Thrift Wood, about a mile north-east from the Church, you may see 'Gold Copse' marked on the Ordnance Survey (Map)."

Curiously enough, whilst the above correspondence was proceeding between Mr. Crouch and myself, an old book was brought under my notice by Miss Higgins, of Luton. It is entitled "Geology and History of England," Dodsley, Pall Mall, no date (probably fifty years old). Under the heading Bedfordshire, p. 3, it says: "At Pulloxhill, near Ampthill, some years ago a gold mine was discovered, but it is now entirely neglected, the profit falling short of the expense of extracting the metal from the ore." As the book from which this extract is taken is simply a compilation, its authority is very doubtful, and it may fairly be assumed that the operations in search of gold have been referred to erroneously as though they had been successful in a limited degree.

Apparently in every instance the seekers have been deceived by the glitter of the iron-stained mica, and have never found any of the precious metal, at least in appreciable quantity.

Some idea of the thickness and average dip of the beds that underlie Luton may be obtained from the data furnished in sinking the artesian well at the Luton Waterworks, and from a solitary record that is left of the boring at the Old Brewery in Park Street, Luton. Through the courtesy of the engineer of the waterworks, the writer was enabled to see the material brought up from the workings. In boring the well, the various beds of the Middle and Lower Chalk were passed through until a depth of 224 feet was reached, when the Chalk Marl was touched, identical in colour and consistency with what one finds at Chalton cutting, close to the bridge, some four miles N.W.; say about 30 feet from the surface. This would give approximately a dip of about 45 feet per mile. The boring was continued over 90 feet through this bed without reaching its base, when the workings were stopped at a depth of 322½ feet from the surface. It was found that there was no increase in the water-supply after passing into this stratum.

The only record known to myself of the artesian well at the Old Brewery, Park Street, Luton, is on a large brick in the outer wall of the market-room of the Cock Inn just opposite the Old Brewery. This brick was made from the material brought up from the bottom of the boring, and bears the following inscription: "F. Burr, 465 feet, Jan. 1828." From its appearance the brick is made from Gault, but there is nothing to indicate from what depth that clay was obtained, except that the surface of the Gault must be just below the bottom of the waterworks boring, say at 325 feet, so the brick must be made from clay 140 feet down in the Gault.

The pleasing duty now remains to acknowledge my deep indebtedness to Mr. Jukes-Browne for his unwearied kindness in naming the chalk fossils, and in other ways; also to Messrs. Whitaker and Newton, as well as other members of the Staff of the Geological Survey, for their valuable assistance and suggestions during the preparation of these notes.

FOSSILS FROM SOUTH BEDFORDSHIRE.

SPECIES.	Upper Chalk.	Chalk Rock.	Middle Chalk.
Ventriculites mammilaris	x		
,, *impressus*	x	x	
,, *angustatus*	...	x	
,, *alcyonoides*	...	x	
Camerospongia, sp. nov.	...	x	
Verrucocœlia tubulata	...	x	
Plocoscyphia flexuosa	...	x	
,, sp. ?	...	x	
Parasmilia centralis ?	...	x	
Micraster cor-testudinarium	x	x	
,, *cor-anguinum*	x		
Holaster cor-avium	...	...	x
Ananchytes ovatus	x		
Galerites globulus	x		
,, *sub-rotundus*	...	...	x
,, *conicus*	x		
Discoidea Dixoni	...	...	x
Salenia granulosa	x		
Cidaris Merceyi	x	...	x
,, *hirudo* ?	x		
,, *sceptrifera*	...	...	x
Cyphosoma Kœnigii	...	...	x
Serpula plana	x		
,, *granulata*	...	x	
Terebratulina gracilis	x		
Terebratula semiglobosa	x		
,, ,, var. *bulla*	...	x	
Rhynchonella plicatilis	x	x	
,, ,, var. *octoplicata*	x	x	
,, *Cuvieri*?	x	x	
Pecten Beaveri	x		
,, *quinquecostatus*	x		
Lima spinosa	x	x	x
,, *striata* ?	...	...	x
Spondylus latus	x		
Ostrea larva	x		
,, sp. ?	...	...	x
,, sp. nov. ?	x		
,, *vesicularis*	x		
,, ,, var. *Baylei*	...	...	x
,, *Normanniana*	x		
Exogyra haliotoidea	...	...	x
Inoceramus Brongniarti	...	x	x
,, sp. ?	x		
,, sp. ?	...	x	

Species.	Upper Chalk.	Chalk. Rock.	Middle Chalk.
Hippurites Mortoni	..	...	x
Cypricardia trapezoidalis	...	x	
Pleurotomaria perspectiva ?	...	x	
Turbo gemmatus	...	x	
Trochus (cast)	...	x	
,, sp. nov.	...	x	
Natica (cast)	...	...	x
Cinulia (cast)	...	x	
Helicoceras, sp. nov.	...	x	
Scaphites Geinitzia	...	x	
Ammonites prosperianus	...	x	
Nautilus lævigatus	...	x	
Belemnitella mucronata, var. *quadrata*	x		
Rhyncholites	x	...	x
Ptychodus mammilaris	x	x	
,, *latissimus*	x	...	x
,, sp. ?	...	x	
Enchodus halocyon	x		
Corax heterodon (from Harpenden, Herts) ...	x		
Lamna acuminata	x	...	x
Otodus appendiculatus	x		
,, sp.	...	x	

Fossils from the Chalk Rock between Luton and Chiltern Green, other than those mentioned above, in the Collection of Dr. Morison. See "Trans. Herts Nat. Hist. Soc. vol. v. Dec. 1889."

Ventriculites radiatus
,, *muricatus*
Camerospongia campanulata
Cephalites perforata
Coscinopora infundibuliformis
Plocoscyphia convoluta
Polyjerea, sp.
Guettardia deltata
,, *stellata* ?
Placotrema cretaceum
Micraster breviporus
,, *cor-bovis*, var.
Holaster planus
,, *trecensis*
,, sp. nov.
Cyphosoma radiatum
Serpula plexus
Balanus, sp.
Rhynchonella Mantelli
Terebratula biplicata
,, *carnea*

Ostrea Normanniana ?
Lima Hoperi
Inoceramus latus
,, *mytiloides*
Mytilus, sp. ?
Arca galliennia
,, sp.
Cardita tenuicosta ?
,, sp.
Trochus Marcaisi
Avellana, sp.
Rostellaria (two undetermined sps.)
Turritella, sp.
Ammonites varians ?
Scaphites æqualis
Baculites, sp.
Ancyloceras, sp.
Heteroceras, sp.
Turrilites senequierianus ?
Corax falcatus (tooth)

Fossils from the Melbourn Rock (Middle Chalk) and Belemnitella plena zone (Lower Chalk) between Leagrave and Luton.

Melbourn Rock.

Ostrea vesicularis, var. *Baylei*. Abundant.

Belemnitella plena zone.

Rhynchonella Cuvieri.
,, *plicatilis.*
Lepas (Crustacean).

Ostrea vesicularis, var. *Baylei.*
Ptychodus decurrens.
Lamna gracilis.

Species.	Lower Chalk.		Totternhoe Stone.		Chalk Marl.	
	Chalton.	Other localities.	Chalton.	Totternhoe.	Chalton.	Basement Bed, Barton, and near Hexton.
Pollicipes glaber	x					
Flabellina, sp. ?	...	x				
Ventriculites	x					
Trococyathus, sp. ?	x					
,, *conulus*	...	...	...	...	...	x
,, *Harveyanus* ...	...	...	...	...	...	x
,, *angulatus*, sp. ?...	...	...	...	...	...	x
Micrabacia coronula	...	...	...	...	...	x
Pseudodiadema Carteri ...	...	...	...	...	...	x
Cidaris Bowerbankii	...	x				
Serpula annulata	x	x				
Palæocorystes Stokesii	...	...	...	...	...	x
Palæga Carteri	...	...	x	...	x	
Rhynchonella Mantelliana	x	...	x	..	x	
,, *sulcata*	...	...	...	...	...	x
,, *grasiana*	x	...	x	...	x	
,, *Martini*	...	...	...	...	x	
,, *Cuvieri*	x	x				
Terebratula striata	...	...	...	...	x	
,, *semiglobosa* ...	...	...	x	...	x	
,, *biplicata*	...	...	...	...	x	x
,, ,, var. *obtusa*	...	...	...	...	...	x
Magas pumilus	x					
Lima echinata ?	x					
,, *aspera*	...	...	...	...	x	
Spondylus gibbosus	...	...	...	...	...	x
Plicatula inflata	x	...	...	...	x	
,, *pectenoides*	...	...	x	...	x	
Pecten quinquecostatus ...	x	...	...	...	x	
,, *fissicosta*	..	...	x			
,, *Beaveri*	...	...	x			
,, *orbicularis*... ...	...	...	x	x		
Ostrea carinata, var. *frons*	...	...	...	...	...	x
Dentalium (cast)...	x	...	x			
,, *ellipticum*	...	...	...	...	...	x
Pleurotomaria (cast)	x					
Aporrhais subtuberculata ...	x					
Solarium ornatum	...	...	...	...	...	x
Turrilites Mantelli	x	...	x			
Ammonites varians	x					
,, *Coupei*	...	...	...	...	x	
,, *Studeri*	...	...	...	...	...	x
,, *rostratus*	...	...	...	...	...	x
Nautilus, sp. ?	x					
,, *elegans*	...	x	x			
,, *clementinus* ...	...	...	...	...	...	x
Belemnites minimus	...	...	...	...	...	x
,, sp. ? near *plena*	...	...	x			
Coprolites	x	x				
Casts of Ganoid Scales ? ...	x					
Ptychodus decurrens	...	x				
,, *latissimus*	...	x				
Notidanus microdon	...	x				
Lamna, sp. ?	x					

Species.	Lower Chalk.		Totternhoe Stone.		Chalk Marl.	
	Chalton.	Other localities.	Chalton.	Totternhoe.	Chalton.	Basement Bed, Barton, and near Hexton.
Odontaspis gracilis	...	x				
Oxyrhina macrorhiza? ...	...	...	...	...	...	x
Cimolichthys striatus? ...	...	x	...	x		
Otodus appendiculatus ...	..	x	x	...	...	x
Plesiosaurus, sp.?	...	...	...	...	...	x
Ichthyosaurus campylodon...	...	...	x			
,, sp.?	...	...	...	...	...	x
Polyptychodon interruptus ...	...	...	...	...	...	x

Fossils from the Lower Greensand, Millbrook, Beds.

Sphærodus neocomensis.
Pycnodont, teeth (young).
Acrodus reticulatus.
Asteracanthus? dorsal spine, incomplete.
Ichthyosaurus, *Dakosaurus*?, *Polyptychodon*, *Plesiosaurus* } teeth, some derived from the Oxford Clay.

An undescribed tooth, thought by Mr. E. T. Newton to be Reptilian.

Fossils from Ampthill, Beds.

Limestone Bands.

Cidaris florigemma, Phil.
Exogyra nana, Sby.
Pinna lanceolata, Sby.
Ostrea gregaria, Sby.
Trigonia irregularis? Seebach.
Alaria trifida, Phil.

Oxford Clay.

Pentacrinus.
Cidaris Smithii, Wright.
Serpula tricarinata? Sby.
Rhynchonella varians, Schloth.
Gryphea dilatata.
Belemnites hastatus, Blain.
,, *sulcatus*, Mill.
Belemnites Owenii, Pratt.
Ammonites cordatus, Sby.
,, *plicatilis*, Sby.
,, *athletus*, Sby.
,, *biplex*, Sby.
,, near *Toucasianus*, d'Orb.
Ichthyosaurus.

REVIEWS.

I.—A Manual of Palæontology for the Use of Students, with a General Introduction on the Principles of Palæontology. By Henry Alleyne Nicholson, M.D., D.Sc., F.G.S., etc., Regius Professor of Natural History in the University of Aberdeen, and Richard Lydekker, B.A., F.G.S., etc. Third Edition. Re-written and greatly enlarged. In Two Vols. Royal 8vo. pp. 1624, with 1419 Woodcut Illustrations. (William Blackwood & Sons, Edinburgh and London, 1889.)

(*Continued from page* 87.)

In a work undertaken by two or more authors, it is always difficult to secure uniformity of treatment; and a few striking differences are observable in the two volumes before us. As already remarked, while the microscopical characters of all the principal skeletal tissues met with in each division of the Invertebrata are not merely described but well illustrated, not a single figure is devoted to the histology of the Vertebrata, and there are no descriptions of tissues that can be regarded as precise or in all respects accurate. Again, the excellent plan of printing in italics concise definitions of each of the great groups, adopted throughout the first volume, is not followed in the second; and the insertion among the figures of Vertebrata of several woodcuts, whose only interest consists in their antiquity, and of which the accuracy is in inverse proportion to their age, forms a striking contrast to the selection of figures employed for the illustration of the Invertebrata.

A brief general statement of the principal characters of the Vertebrate skeleton follows the definition of the sub-kingdom; and each class is subsequently treated in more detail at the head of the section relating to its extinct representatives.

In the general description of the Class Pisces, the absence of any precise description of the histology of the exoskeleton is especially unfortunate; and even more so is the allusion to Selachian dermal tubercles as "bony" and "supported on bone." One of the more frequent problems to be solved by the Palæichthyologist has reference to the true nature of detached fragments of the dermal armour of fishes; and the differences between (i) the vascular dentinal structure characteristic of Elasmobranchii and Chimæroidei, (ii) the isopedin of some of the earlier "Ganoids," and (iii) the true bone of Sturgeons and other "Ganoids," are so distinct and noteworthy, that the most elementary guide to the student ought to provide detailed descriptions with figures. The illustrations of cycloid and ctenoid scales (figs. 832, 833) will also prove somewhat confusing; the smooth posterior border being directed downwards in the first, and the prickly homologous border turned upwards in the second. The statement that there are no neural and hæmal arches in the vertebral column of Sharks (p. 915) is rightly contradicted by descriptions and figures in the following chapter; and the brief allusion to the "pelvis" on p. 919 is scarcely so explicit as desirable. The earliest known fishes are not Placodermata (as stated), but Pteraspidians; and, following the latest researches, the author dismisses conodonts with a brief mention, illustrated by the familiar figure. The classification proposed by Huxley, in 1876, is adopted, each of the six divisions being termed orders, and all except the first (Cyclostomi) having undoubted extinct representatives.

The Elasmobranchii are treated for the most part in accordance with the British Museum Catalogue; and the singular family of Squaloraiidæ is placed in the Chimæroidei on the authority of Dr. Traquair. The Dipnoi comprise the Lepidosirenidæ, Ceratodontidæ, Phaneropleuridæ, and Dipteridæ; and the Ganoidei follow, arranged and subdivided as suggested by Dr. Traquair. Here, unfortunately, some minor inaccuracies occur, and the selection of several of the woodcuts is far from satisfactory. The canals of the "lateral line," for instance, have only been found in the Pteraspidæ, not in the Cephalaspidæ; there are no Lower Devonian rocks in "North

Wales," *Holaspis* having been discovered in Monmouthshire; and *Didymaspis* is not Silurian, but Devonian. It is correctly stated that *Scaphaspis* has proved to be the ventral shield of *Pteraspis*; nevertheless, Lankester's erroneous figure with the mouth in the middle of the truly armoured abdominal region still survives. It would perplex any one but a specialist to comprehend the old figure of *Cyathaspis*; and the anal fin is even yet retained in the restoration of *Coccosteus*, notwithstanding M'Coy's assertion, thirty years ago, that such a feature did not exist in the numerous specimens he had examined, and that Agassiz's determination of its presence was doubtless founded on a mistake. It was excusable fifty years ago to make use of a Teleostean head to impart a life-like form to the dilapidated trunk of a Devonian Ganoid; but the progress of research ought, by this time, to have exterminated so fundamental an error. We are thus astonished to find Agassiz's restoration of *Dipterus* once more repeated (fig. 907), and, not only so, but now labelled *Thursius macrolepidotus*, through an unfortunate misunderstanding of recent researches. Huxley's restorations of Cœlacanths, with their broom-like dorsal fins, still persist, in spite of von Zittel's beautiful engraving of *Undina*; and a beginner might well be excused for failing to recognize a Sturgeon from the old caricature on p. 975. Most of the other figures of Ganoids, however, are satisfactorily up to date; the only serious inaccuracy occurring in Agassiz's restoration of *Aspidorhynchus*, where the rostrum, as well as the upper jaw, is shown to be provided with teeth.

In the arrangement of the Teleostei, Dr. Günther's classification is adopted; and the only important additions to the scheme occur in the section upon the Cretaceous forms. The provisional groups from the Chalk, distinguished by Smith Woodward, are named and regarded as families of Physostomi; and most of the genera are treated in accordance with the determinations of the same author. The enumeration of the extinct representatives of the later families will prove useful for reference, though somewhat uninteresting reading; and the majority of the illustrations are both artistic and accurate. The usual bibliography follows, with references to most of the principal works and memoirs; but we venture to suggest that the omission to record any of Egerton's contributions to the subject beyond a single brief technical note of limited interest, is scarcely doing justice to one of England's foremost palæontologists.

As may naturally be supposed, the chapter devoted to the Amphibia is chiefly concerned with a discussion of the Labyrinthodonts. These form an order, subdivided (after Anton Fritsch) into "four series or suborders, according to the external contour of the body and the nature of the vertebral column." The Bohemian *Branchiosaurus* is regarded as identical with the French *Protriton*; *Platyceps*, from the Australian Hawkesbury Beds, is said to be probably the same as *Bothriceps*, also Australian; and the South African genus, *Rhytidosteus*, is provisionally arranged with the Archegosauridæ. *Eosaurus* is degraded from its Reptilian rank held in the last edition of the work, and now rightly appears as a Labyrinthodont *incertæ* *sedis.* Among later Amphibia, the family Hylæobatrachidæ is proposed for the Wealden Caudate genus *Hylæobatrachus* of Dollo; and the description of the Ecaudata is well up to date, though some reference might have been made, at least in the table of "Literature," to the recent elaborate researches of Wolterstorff.

In the Reptilia, the great groups are arranged chiefly according to the system proposed by George Baur. Four diverging "branches" are recognized, and it is remarked "that the close approximation to the Amphibia presented by the earlier members of several of these branches suggests the idea that Reptiles may have been derived from the Amphibians by more than one line of descent." The so-called order Proganosauria is thus rejected; and "the manifest affinity of [its type-genus] *Mesosaurus* to the more typical Sauropterygia, and of *Palæohatteria* to the Rhynchocephalia, seem to render it more advisable to refer those genera to the two orders in question, of which they will respectively form the most generalized stage."

The Theromorous Branch of Reptiles is regarded as comprising only a single order, that of Anomodontia, noteworthy for the resemblance of many of its features to those of the Labyrinthodont Amphibia, and of the Monotreme Mammalia. The order appears to be confined to the Permian and Trias, and is subdivided into Pariasauria, Theriodontia, Dicynodontia, and Procolophonia. *Pariasaurus* is noticed as described by Seeley; and *Anthodon,* also from the Karoo System, is included in the same family. The gigantic Anomodonts, *Tapinocephalus* and *Titanosuchus*, from the Karoo, form the first family of Theriodonts, and the pelvis named *Phocosaurus* is recorded as not impossibly referable to the former. The Placodontia are placed, as a group of uncertain rank and position, between the Theromorous and Synaptosaurian Branches; and the interesting fact is noted, that all known limb-bones from the Muschelkalk, in which the skulls of *Placodus* occur, are either Dinosaurian or Sauropterygian. The Synaptosaurian Branch comprises the orders of Sauropterygia and Chelonia, illustrated by numerous good figures; and the last-named order is further divided into the suborders of Athecata and Testudinata (Thecophora), in accordance with the researches of Cope, Boulenger, and Dollo. The opposite view of Baur is mentioned, but the Athecata are provisionally adopted as the more primitive (not degenerate) type; and "before a decisive opinion can be given on this question, it must be determined whether the absence of a bony connection in this group between the parietals and pterygoids is to be regarded as an acquired or as an original feature." The Streptostylic Branch comprises the orders Ichthyopterygia, Proterosauria, Rhynchocephalia, and Squamata, and the opening paragraph of the chapter relating to these is an interesting study in the complexity of taxonomy and nomenclature. All the Ichthyosauria are included in a single family; and in the Addenda (p. xi) the species *Ichthyosaurus platyodon* is made the type of a new genus, *Temnodontosaurus.* The Rhynchocephalia are divided into the suborders of Simædosauria, Sphenodontina, and Homæosauria, and *Palæohatteria* is placed first in a doubtful subordinal position.

Although the position of the mandible in Huxley's restoration of the head of *Hyperodapedon* is rightly stated to be erroneous, the figure is repeated without emendation; and, it may be added, materials are forthcoming for a much more accurate view of the skull of *Rhynchosaurus* than is given in the old woodcut, fig. 1038. With the exception of the Pythonomorpha, the groups of Squamata are not of much palæontological interest; but known facts are fully summarized, and the chapter ends with the portrait of a living Cobra. The Archosaurian Branch consists of the three orders, Dinosauria, Crocodilia, and Ornithosauria, which include the most highly developed and largest Reptiles, and make the nearest approach in their organization to the Avian type. The recently proposed subdivision of the Dinosauria into two orders is mentioned, but not adopted, and the so-called Stegosauria are merged with the suborder Ornithopoda. A restoration of *Megalosaurus* is copied from Mansel-Pleydell's Synopsis of the Dorset Fossil Reptiles; and the complex story of the British Atlantosauridæ is briefly related on p. 1175. The Aetosauria and Parasuchia are retained among the Crocodiles, and the Eusuchia form a third suborder, including Huxley's Mesosuchia, and divided into an amphicœlian and a procœlian series. In the account of the Ornithosauria the most important memoir of recent years (E. T. Newton, On *Scaphognathus Purdoni*, Phil. Trans. 1888) is singularly ignored; and we once more meet with woodcuts that are so well known to be erroneous that the impressions they give are even corrected in the text. It is time that such misleading and now exploded guesses at truth as those embodied in figs. 1095 and 1099 were consigned to the limbo of early palæontological failures. The omission to include the memoir of Newton just mentioned in the literature of the subject is also somewhat unfortunate; for this is accompanied by an appendix giving the most complete bibliography of Ornithosauria hitherto compiled.

The chapters on Aves are arranged chiefly in accordance with Prof. Alfred Newton's scheme of classification; and Dr. Gadow's latest researches on the Ratitæ are also mentioned. Many good illustrations are introduced, but a figure of the Berlin *Archæopteryx* would have been a desirable addition. Mr. E. T. Newton's well-known memoir on *Gastornis* ought also to have been noticed in the literature of the subject.

The general introduction to the Mammalia, which chiefly concerns the skeleton, is followed by an interesting sketch of the evolution of the class, so far as known. The classification adopted is that of Professors Flower and Huxley, and the latest discoveries all appear to be duly incorporated. The Mesozoic group of Multituberculata is provisionally placed among the Prototheria; while the numerous polyprotodont jaws of the same epoch are assigned to the Metatherian Marsupials. In the treatment of these early forms, Prof. H. F. Osborn's observations are largely quoted, and three of Professor Marsh's new figures are added. Among later Marsupials, the genera described by Sir Richard Owen from Australia are most conspicuous; but the upper incisors of *Diprotodon* in fig. 1155 are inaccurately drawn, and the old erroneous theoretical restoration of the mandible of *Thylacoleo* is once more repeated, notwithstanding Sir Richard Owen's description of the actual fossil five or six years ago. In the Phalangeridæ, the premolar slopes outwards, not inwards as stated (p. 1286); and as regards *Bradypus didactylus* among the Sloths (p. 1300), we would remark that it is identical with *Cholœpus didactylus*, having two toes on the fore foot and three on the hind foot. A new figure of *Scelidotherium* by Prof. Capellini is added, from the Bologna Report of the International Geological Congress; and the extinct European genera, *Macrotherium* and *Ancylotherium*, are removed from the Edentates to the primitive Ungulates, adopting the recent determinations of Dr. Filhol. The name *Nothrotherium* is substituted for the pre-occupied *Cœlodon* (p. 1299): and the recent discovery of a Pangolin (*Palæomanis*) in the Isle of Samos is recorded. The Cetacea and Sirenia are fully treated, and the very long section on the Ungulata is profusely illustrated. The well-known evidences of evolution in the various types are pointed out, and several original observations are recorded. The resemblance between the skull of the newly-described *Samotherium* and that of the antelopoid genus, *Palæotragus*, is remarked upon; and the so-called *Macrotherium sivalense*, from the Siwalik formation, is placed in the Chalicotheriidæ, like its European representatives determined by Dr. Filhol. Prof. Marsh's new restoration of *Titanotherium* (or *Brontops*) *robustum* and Prof. Cope's figure of *Phenacodus primævus* are added; and the so-called *Dinoceras* and *Tinoceras*, from the Bridger Eocene of the United States, are described as identical with *Uintatherium*. For various reasons, however, Prof. Marsh does not adopt this earlier name, and the quotation on p. 1390, from that author, should have been precise. The enumeration of the extinct Rodentia is elaborate, though with few figures; and then follow the Carnivora, occupying thirty pages, illustrated by nearly forty woodcuts. Among the latter are valuable lateral views of the detached dentition of the Seal, Dog, and Bear; and the family Ursidæ, as in the author's previous publications, is defined as including both Dogs and Bears.

The last chapter is devoted to the Insectivora, Cheiroptera, and Primates; the former two orders being illustrated by figures chiefly of existing types, while some interesting figures recently published by Prof. Cope are incorporated in the account of the Lemuroid Primates. Nearly seventy works and memoirs are enumerated in the literature of the Mammalia, and we would add one more from which information has been obtained for the text, namely, Mr. E. T. Newton's Memoir on the Vertebrata of the Forest Bed.

The volume concludes with a section on Palæobotany, giving "an extremely brief and entirely general sketch of the past distribution and succession of the chief types of plant-life." This part of the work has been compiled by both the authors jointly, and numerous figures not given in the earlier editions are added. The bibliography is fully detailed, but Mr. Kidston's memoir on the Radstock Coal-plants, we observe, has been ascribed to another author.

In an appendix, several publications that have appeared during the progress of the work are briefly noticed; and one of the footnotes is a protest against the making of such "uncouth" and "barbarous" names as *Wardichthys* and *Leedsichthys*. By some strange oversight, however, the most "barbarous" of all such names, *Gondwanosaurus* of Lydekker, is omitted from this category. The index of genera occupies about fifty pages, and almost every palæontological form of importance seems to be included.

II.—Contributions to the Micro-Palæontology of the Cambro-Silurian Rocks of Canada. Pt. II. pp. 27–57, with Two Lithographed Plates and Two Woodcuts. By E. O. Ulrich. (Geological and Natural History Survey of Canada. Montreal: W. F. Brown & Co., 1889.)

THIS is in continuation of Mr. A. H. Foord's previously published Report,[1] and the pagination and numbering of the plates of the two parts have therefore been made consecutive. The present Report (No. 4 of the series) is entitled "On some Polyzoa (Bryozoa) and Ostracoda from the Cambro-Silurian Rocks of Manitoba," and the author states in a brief introduction that his material consisted of a small collection of specimens made at various times between the years 1875–84, both inclusive, by different members of the Canadian Survey, but mostly by Mr. T. C. Weston.

The species of Polyzoa described include twenty from Stony Mountain,[2] five from St. Andrew's,[3] and one from Big Island, Lake Winnipeg. All the Stony Mountain species belong to the Hudson River Group, while of the St. Andrew's species two, *Monticulipora Wetherbyi*, Ulrich, and *Pachydictya acuta*, Hall, occur in the Birdseye and Black River Formation, and the other three (enumerated below) in the Trenton.

The following are the names of the Stony Mountain species:—

Proboscina auloporoides, Nicholson.
Proboscina frondosa, Nicholson.
Monticulipora parasitica, Ulrich, var. *plana*, n.var.
Homotrypa, sp. undescribed.
Batostoma Manitobense, n.sp.
**Petigopora scabiosa*, n.sp.
Batostomella gracilis, Nicholson (var.).
**Bythopora striata*, n.sp.
Bythopora ? *delicatula*, Nicholson.
Monotrypella quadrata, Rominger.
Stictopora or *Rhinidictya*, sp. indt.
Dicranopora fragilis, Billings.
Dicranopora emacerata, Nicholson.
Goniotrypa bilateralis, n.gen. and sp.
Pachydictya hexagonalis, n.sp.
Ptilodictya Whiteavesi, n.sp.
Arthroclema angulare, Ulrich.
Helopora Harrisi, James.
Sceptropora facula, Ulrich.
Nematopora ?, sp. undescribed.

The St. Andrew's species are:—*Monticulipora Wetherbyi*, Ulrich, *Fistulipora* ? *laxata*, n.sp., **Pachydictya magnipora*, n.sp., *Pachydictya acuta*, Hall, and *Phylloporina Trentonensis*, Nicholson, sp. The species from Big Island, Lake Winnipeg, is named *Diplotrypa Westoni*, n.sp.

[1] Contributions to the Micro-Palæontology of the Cambro-Silurian Rocks of Canada, pp. 1–26, 7 plates and 1 woodcut, Ottawa, 1883.

[2] A hill some fifty feet in height, on the western bank of the Red River, not far from Winnipeg.

[3] A village and parish on the west bank of the Red River, about fifteen miles north-east of Winnipeg.

All the new species are figured, except the three distinguished by an asterisk; these probably were too thin or fragile to admit of the process of grinding into thin sections.

Under the description of *Diplotrypa Westoni*, Mr. Ulrich proposes a new family—*Diplotrypidæ*—to include (provisionally) the two genera *Diplotrypa* and *Monotrypa*, the author suggesting that it may be found necessary to break up each of these into two, but that further study and detailed comparisons are required before a final arrangement with regard to them can be effected. This he promises to bring about in a forthcoming work on Illinois Polyzoa.

The Ostracoda described in this report are, with one exception—*Eurychilina reticulata*—all from Stony Mountain, and consist of the following species:—

Bythocypris cylindrica, Hall, sp.
Leperditia subcylindrica, n. sp.
Aparchites minutissimus, Hall, sp.
Aparchites unicornis, Ulrich, n. var.
Primitia lativia, n. sp.
Primitia ? (? *Beyrichia*) *parallela*, n. sp.
Eurychilina reticulata, n. gen. and sp., (from the Trenton shales of Minnesota.)
Eurychilina Manitobensis, n. sp.
Strepula quadrilirata, Hall and Whitfield, sp., var. *simplex*, n. var.
Strepula lunatifera, n. sp.

The author expresses his great obligations to Prof. T. Rupert Jones, F.R.S., for critical notes on these species.

The report concludes with a table prepared to show the stratigraphical range of those Manitoba species of Polyzoa and Ostracoda which have been found also in the United States, and from this we learn that out of 29 species from Stony Mountain, 20 are known to occur in the upper beds of the Hudson River or Cincinnati Group at localities in the United States.

The Canadian Survey is to be congratulated on having secured the services of so careful and experienced a worker as Mr. Ulrich for the difficult groups forming the subject of this report.

A. H. F.

III.—Descriptions of Eight New Species of Fossils from the Cambro-Silurian Rocks of Manitoba. By J. F. Whiteaves. From Trans. Royal Soc. Canada, Section iv. Nov. 1889, p. 75. Six Plates. (Montreal, Dawson Brothers.)

FOSSILS from such a distant region as Manitoba are valuable, not only as an index to the age and distribution of the rocks on the great continent of which that province forms a part, but also as attesting the interest taken in Geology by a people whose pursuits must leave them but little leisure for purely scientific studies. Nevertheless we find from Mr. Whiteaves' paper that some of the most notable of the fossils described by him were collected by members of the "Manitoba Historical and Scientific Society," and by that Society presented to the Museum of the Canadian Survey (Ottawa).

The species described, though numbering only eight, represent six genera, the first of which is a Gasteropod, and the rest Cephalopods, as follows:

Maclurea Manitobensis.	*Oncoceras gibbosum.*
Poterioceras nobile.	*Cyrtoceras Manitobensis.*
,, *apertum.*	*Trochoceras McCharlesi.*
Oncoceras magnum.	*Apsidoceras insigne.*

Maclurea Manitobensis is of very large size, attaining a maximum diameter of eight inches and a half. It is said to be more nearly related to the *M. Bigsbyi* of Hall, from the Trenton Group of Southern Wisconsin, and to the *M. cuneata* of R. P. Whitfield, from the Galena Limestone of the same State, than to either *M. magna*, Hall, or *M. Logani*, Salter.

To the genus *Poterioceras* two species are assigned—*P. nobile* and *P. apertum*; the first of these is referred provisionally to this genus "on account of its supposed simple and entire aperture," "but," adds the author, "it may prove to be a true *Gomphoceras*."

Mr. Whiteaves disagrees with Prof. Blake's view that *Oncoceras*, Hall, is synonymous with *Poterioceras*, M'Coy, and observes that the latter name "will probably have to be restricted to those straight, *Gomphoceras*-like shells in which the aperture is simple and entire"; in *Oncoceras*, on the other hand, "the shell is always distinctly curved and inflated in a peculiar manner in advance of the mid-length, while its body-chamber is transversely constricted just behind the aperture." It is thus seen that Mr. Whiteaves' contention in favour of the distinctness of *Poterioceras* and *Oncoceras* rests upon the assumption that the latter has a curved and inflated shell, and the former a straight, *Gomphoceras*-like shell. The constriction near the aperture can scarcely be reckoned as a distinctive generic character, because it is met with also in some species of *Orthoceras*. With regard to the inflation of the shell, that is a character common to both forms, as is admitted for *Poterioceras* in the expression "*Gomphoceras*-like"; and as to curvature, abundant proof exists that *Poterioceras* has a slightly but quite distinctly curved shell; this is seen in numerous specimens from the typical locality—Kildare, Ireland—whence M'Coy obtained the material upon which he constructed his genus. There therefore appears to be very little ground for separating *Poterioceras* from *Oncoceras*.

On looking at the figure of *Poterioceras nobile*, one is indeed struck with its *Gomphoceras*-like aspect, and the doubt expressed by the author as to whether it is really a *Poterioceras* will probably be shared in by most palæontologists who examine it in the light of the more recent researches in these fossils.

The uncertainty regarding the oral characters of such forms as these leaves room for considerable diversity of opinion as to the genus to which they belong, but our experience so far is opposed to their reference to the genus *Gomphoceras*, no fossil having yet been found below the Upper Silurian in which the complex, lobed aperture, characteristic of *Gomphoceras*, is preserved. This important structure being unfortunately absent in Mr. Whiteaves' specimens, the latter do not help us to settle the question of the range in time of *Gomphoceras*.

The species named *Cyrtoceras Manitobensis* is a very aberrant form of this genus, if indeed it really belongs to it, the presence of longitudinal to the entire exclusion of transverse ornaments being a feature hitherto unknown in other species of the genus. A. H. F.

IV.—Hampstead Hill: Its Structure, Materials, and Sculpturing. By J. Logan Lobley. With Chapters on the Natural History of the District by H. T. Wharton, F. A. Walker, and J. E. Harting. 8vo. pp. 100. With Nine Plates. (London, 1889.)

A USEFUL and readable companion to this interesting bit of country which is carefully described and well illustrated. After describing the geological structure of the Heath in detail, the author reprints a series of well-sections from Mr. Whitaker's "London Basin," gives a list of fossils which surprises by its fulness, and appends a useful bibliography, to which, however, may be added: John Bliss, Experiments and Observations on the Medicinal Waters of Hampstead and Kilburn. 4to. London, 1802, pp. 58,—a pamphlet which seems to have escaped bibliographers in general. There is also a mistake in the date of Goodwin's account of the Saline Waters; this interesting little book was published in 1804, the author apologizing for the delay in publication in his preface. Goodwin also adds a view of Pond Street in 1803 and gives a careful and accurate map of "Hampstead with some of the adjacent villages, and surrounding rides, 1803." Dr. H. T. Wharton contributes a list of the Plants, the Rev. F. A. Walker, one of the Insects, etc., and Mr. J. E. Harting writes on the Birds, giving notes of dates of appearance of the rarer visitors and accurate information as to their nesting places. Professor Lobley has wisely reproduced, by permission of the Council of the Geologists' Association, the late Mr. Caleb Evans' geological sketch map of Hampstead. C.D.S.

V.—Mount Vesuvius: A Descriptive Historical and Geological Account of the Volcano and its Surroundings. By J. Logan Lobley. 8vo. With Maps and Illustrations. (London, 1889.)

THIS new and revised edition of Professor Lobley's book fills up a gap in the literature of Vesuvius. The most recent memoirs on the subject have been laid under contribution, and the book is both readable and comprehensive.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 22, 1890.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communication was read:—

"On the Crystalline Schists and their Relation to the Mesozoic Rocks in the Lepontine Alps." By Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

In the debate upon the paper "On two Traverses of the Crystalline Rocks of the Alps" (read Dec. 5, 1888) it was stated that rocks had been asserted on good authority to exist in the Lepontine Alps, which contained Mesozoic fossils, together with garnets, staurolites, etc., and thus were undistinguishable from crystalline schists regarded by the author as belonging to the presumably Archæan *massifs* of that mountain-chain. In reply, the author stated that he regarded this as a challenge to demonstrate the soundness or unsoundness of the hypothesis to which he had committed himself. The present paper gives the result of his investigations, undertaken in the month of July, 1889, in company with Mr. James Eccles, F.G.S., to whom the author is deeply indebted for invaluable help. The paper deals with the following subjects:—

(1) *The Andermatt Section.*

By the geologists aforesaid, a highly crystalline white marble which occurs on the northern side of the Urserenthal trough, at and above Altkirch, near Andermatt, is referred to the Jurassic series (members of which undoubtedly occur at no great distance, almost on the same line of strike). The author describes the relation of the marble to an adjacent black schistose slate, and discusses the significance of some markings in the former which might readily be considered as organic, but to which he assigns a different origin. He shows that there are most serious difficulties in regarding these two rocks as members of the same series, and explains the apparent sequence as the result of a sharp and probably broken infold, as in the case of the admitted band of Carboniferous rock at Andermatt itself. That the section is a difficult one on any hypothesis the author admits; but after a discussion of the evidence, he concludes that "that tendered on the spot demands a verdict of 'not proven'—that obtainable in other parts of the Alps, will compel us to add, 'not provable.'"

(2) *The Schists of the Val Piora.*

These schists, already noticed by the author in his Presidential Address to the Society in 1886, occur in force near the Lago di Ritom, and consist of two groups:—the one, dark mica-schists, sometimes containing conspicuous black garnets, banded with quartzites, the other various calc-mica schists; between them, apparently not very persistent, occurs a schist containing rather large staurolites or kyanites. On the north side is a prolongation of the garnet-actinolite (Tremola-) schists of the St. Gothard, and then gneiss; on the south side gneiss. There is also some rauchwacké. This rock, at first sight, appears to underlie the Piora-schists, and thus to be the lowest member of a trough. If so, as it is admittedly about Triassic in age, the Piora-schists would be Mesozoic. The author shows that (1) the latter rocks do not form a simple fold; (2) they are beyond all question altered sediments; (3) they have often been greatly crushed subsequent to mineralization; (4) the garnets, staurolites, etc. (if not injured by subsequent crushing), are well developed and characteristic, and are authigenous minerals.

(3) *The Rauchwacké and its Relation to the Schist.*

(*a*) *The Val-Piora Sections.*—The author shows that the rauchwacké, which at first sight seems to underlie the dark mica-schist, is inconstant in position (on the assumption of a stratigraphical sequence); that its crystalline condition does not resemble that of the schist-series, but is rather such as is common in a rock of its age; that it contains mica and other minerals of derivative origin, and in places rock-fragments which precisely resemble members of the Piòra-schist series.

(*b*) *The Val-Canaria Section.*—This section, described by Dr. Grubenmann, is discussed at length. It is shown that the idea of a simple trough is not tenable, for identical schists occur above and below the rauchwacké; that there is evidence of great pressure, which, however, acted subsequently to the mineralization of the schists; and that in one place the rauchwacké is full of fragments of the very schists which are supposed to overlie it.

(*c*) *Nufenen Pass, etc.*—Other cases, further to the west, are described, where confirmatory evidence is obtained as to great difference in age between the rauchwacké and the schists, and the antiquity of the latter. The apparent interstratification is explained by thrust-faulting.

(4) *The Jurassic Rocks, containing Fossils and Minerals.*

The author describes the sections on the Alp Vitgira, Scopi, and the Nufenen Pass. Here indubitable Belemnites and fragments of Crinoids occur in a dark, schistose, somewhat micaceous rock, which is often very full of "knots" and "prisms" of rather ill-defined external form, something like rounded garnets and ill-developed staurolites. These rocks at the Alp Vitgira appear to overlie, and in the field can be distinguished from the black-garnet schists. In one place the rock resembles a compressed breccia, and among the constituent fragments is a rock very like a crushed variety of the black-garnet mica-schist. These Jurassic "schists" are totally different from the last-named schists, to which they often present considerable superficial resemblance; for instance, their matrix is highly calcareous, the other rock mainly consisting of silicates. Some of the associated mica may be authigenous, but the author believes much of it and other small constituents to be derivative. There is, however, a mineral resembling a mica, exhibiting twinning with (?) simultaneous extinction, which is authigenous. The knots are merely matrix clotted together by some undefinable silicate, and under the microscope have no resemblance to the "black garnets." The prisms are much the same, but slightly better defined; they present no resemblance to the staurolites, but may be couseranite, or a mineral allied to dipyre. Hence, though there is rather more alteration in these rocks than is usual with members of the Mesozoic series, and an interesting group of minerals is produced, these so-called schists differ about as widely as possible from the crystalline schists of the Alps, and do not affect the arguments in favour of the antiquity of the latter. In short, they may be compared to rather poor forgeries of genuine antiques. Incidentally the author's observations indicate (as he has already noticed) that a cleavage foliation had been produced in some of the Alpine schists anterior to Triassic times.

Discussion.

Dr. Geikie having sent an abstract of the paper by Professor Bonney, read to the British Association at Newcastle, to Prof. Heim, the latter had favoured him with a résumé of his views on the subject, of which the following is a translation :—

"It appears to me that Professor Bonney starts from a misunderstanding. It has often been maintained that Mesozoic rocks can become crystalline; but *no* Swiss geologist has, so far as I know, *ever* asserted that the crystalline schists of the *Central massif* of the Alps are metamorphic Mesozoic rocks. In the printed abstract of his British Association paper, however, which you have sent to me, Professor Bonney attacks this supposed assertion—one that has never been made.

"I am in perfect accordance with those who know the *Central massif* best (Baltzer, Fellenberg, etc.) in fixing the following points:—

"1. Crystalline schistose rocks of Mesozoic age exist at Scopi, in the Valserthal (Graubünden), in the Userenthal, on Piora, at the Nufenerpass, in the Val Canaria, in the Ganterthal and numerous other places. Such rocks are :—

"(*a*) Clay-slates, with mica, garnets, zoisite, staurolite, rutile, and Belemnites, the latter being crystalline and granular.

"(*b*) Clay-slates, with mica, staurolite, etc., and garnet, alternating with the Belemnite-schists.

"(*c*) Green plagioclase-amphibole schists, alternating with the Belemnite-schists.

"(*d*) Micaceous phyllites and calcareous mica-schists.

"(*e*) Marble with mica, which has undergone linear stretching, going over into 'Malm-kalk' with crinoids.

"We have *never* given the name 'crystalline-schists' to these rocks, nor have we ever regarded them as such, but always as sedimentary metamorphosed zones (synclinal basins) *between* the central massifs. Professor Bonney is right in saying that they have not the aspect of true crystalline schists. It is true there are some varieties which it would be difficult to distinguish in the hand-specimen, and without stratigraphical evidence, from true crystalline schists. Stratigraphically, they always present themselves as 'Mulden-zones' accompanied by other sedimentary rocks.

"In the *Central massifs* occur rocks which exactly resemble true crystalline schists in mode of occurrence. Petrographically, they are related to them by passage-rocks; at least, the line of separation is not easily distinguished. Such rocks are *phyllites*, *chlorite-schists*, *felsite-schists*, *mica-schists*, and especially *sericite-gneisses*, all of which we regard with certainty as palæozoic. The proofs are the following :—

"(*a*) In some places in these zones are found intercalated beds of graphitic and sometimes even anthracitic schists (Brisenstock, etc.).

"(*b*) Traces of fossils have been often found (trunks of Calamites from Guttanen in the Haslithal, Carboniferous plants in strips wedged in on the Tödi, etc).

"(*c*) At the end of the Central-massif distinct zones of Carboniferous slates are often developed out of the zones of these sericitic gneisses; and the synclinal ('Mulden') nature of these zones, in comparison with the old granitic gneisses, is shown there by the wedging in of still younger unaltered sedimentary rocks.

"(*d*) I have already shown in my Tödi-Windgällen group that even the Verrocano (Permian), when nipped in between crystalline schists, assumes a close resemblance to them, and appears as a part of the crystalline Central-massif.

"Fragments of these rocks are found in the Triassic rauchwacké, but this is not the case with the garnetiferous schists of Scopi, which are younger than the Rauchwacké, and belong to the true sedimentary synclinal zones ('Mulden').

"A great unconformity exists in the Central Alps between Palæozoic and Mesozoic formations, but not between Palæozoic and Azoic.

"I. The *Palæozoic* formations mostly show an intimate tectonic relation to the crystalline schists, and have been converted petrographically into crystalline schists. The *central-massifs* consist, perhaps to the extent of two-thirds, of true old crystalline schists, older than the Cambrian, in part, perhaps, the primitive crust (Erstarrungskruste, granite-gneisses, protogine); and to the extent of about one-third of Palæozoic mica-schists, sericite-schists, amphibolites and other similar rocks which have been derived by dynamic metamorphism from Palæozoic slates, sandstones, and conglomerates; and Baltzer distinguishes between the old nucleus and the younger shell (slates) of the *Central-massif.* They are kneaded and pressed into one another.

"II. The genuine Mesozoic deposits follow, sometimes conformably, sometimes unconformably. In places they have become crystalline and schistose (*schiefrig krystallinisch*); but they never occur as a constituent of the *Central-massif*, but always accompany the Mesozoic deposits, or are intercalated as 'Mulden' in, and especially between, the *Central-massifs.* They are never termed 'Crystalline-schists' in the geological sense of the word, at the most only in its petrographical sense.

"The latest literature on these things is, above all:—

"*Baltzer.* 'The Aar-massif and a part of St. Gothard-massif.' 'Beiträge zur geol. Karte der Schweiz. 24th Lieferung, 1888.

"*Grubenmann* (*Prof. Dr.*). 'The Sedimentary "Mulde" of Piora.'

"Baltzer furnishes in the volume above cited some excellent work on the above rocks indicated under I., and gives a drawing of the Calamite-like trunk from Guttanen. Grubenmann does the microscopic work in connection with the Mesozoic formations belonging to II., which have *never* been referred, by us, to the crystalline schists, or to the *Central-massif.*

"Result.

"Much of what have been regarded as genuine crystalline schists in the Alps is Palæozoic.

"The crystalline metamorphosed Mesozoic rocks always occur as sedimentary deposits, and have never been termed "crystalline schists" in the stratigraphical sense."

II.—Feb. 5, 1890.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Variolitic Rocks of Mont-Genèvre." By Granville A. J. Cole, Esq., F.G.S., and J. W. Gregory, Esq., F.G.S., F.Z.S.

The following conclusions were arrived at by the authors as the result of their observations:—

The gabbro or euphotide south of Mont-Genèvre is associated with serpentines, which were originally peridotites, and were not derived from the alteration of the gabbro. These coarsely crystalline rocks probably form a considerable subterranean mass, but have little importance at the surface.

They were broken through by dykes of dolerite and augite-andesite, and are now overlain by a great series of compact diabases and fragmental rocks, which has no direct connexion with the gabbro.

The variolite of the Durance occurs *in situ* as a selvage on the surfaces of contact of these diabases among themselves, as blocks in certain fragmental rocks, which are regarded by the authors as tuffs, and occasionally as a selvage to the diabase dykes.

This product of rapid cooling was originally a spherulitic tachylyte, and has become devitrified by slow secondary action. Variolite thus stands in the same relation to the basic lavas as pyromeride does to those of acid character.

The eruptive rocks in the Mont-Genèvre area are probably Post-Carboniferous, but their exact age cannot at present be determined.

There are several other areas of similar variolitic rocks among both the Alps and the Apennines of Piedmont and Liguria.

The best modern representatives of the conditions that produced these rocks are to be found in the great volcanoes of Hawaii, and there is nothing either in their fundamental characters or in their mode of origin that cannot be paralleled among the products of causes now in action.

The authors expressed their indebtedness to Professors Bonney and Judd, as well as to those who have preceded them upon the classic ground of Mont-Genèvre.

2. "The Propylites of the Western Isles of Scotland, and their Relations to the Andesites and Diorites of the District." By Professor John W. Judd, F.R.S., F.G.S., etc.

The "Propylites" of von Richthofen and Zirkel constitute what has been aptly characterized by Rosenbusch as a "pathological variety" of the andesites. The relations of rocks of this type to the andesites and diorites in Eastern Europe and in the Western Territories of the United States have been made known to us by the researches of Dölter, Szabó, Becker, Hague and Iddings, and other petrographers.

The "felstones" described by the author of the present memoir as constituting the oldest series of the Tertiary volcanic rocks in the Western Isles of Scotland are now shown to belong to this interesting type. When found in an unaltered state, these rocks present remarkable analogies with the andesites of Iceland and the Faroe Islands, which have been so well described by Zirkel, Schirlitz, Osann, and Bréon. In the altered condition in which they usually occur, however, the Scottish rocks resemble in a not less striking manner the "propylites" of Eastern Europe and Western North-America.

The rocks in question vary in colour from white to dark grey, various shades of green usually prevailing among them. They have a specific gravity ranging from 2·4 to 2·9; the density diminishing as the silica percentage and the amount of glassy material in them increase; a lowering of the density of the rocks being also the result of extreme alteration. In their chemical composition these rocks were shown to agree with the pyroxene- and amphibole-andesites of other areas, and with propylitic forms of those rocks.

Very striking and remarkable is the amount of change that many of these Tertiary rocks have undergone—change that has equally affected their porphyritic constituents and the ground-mass in which these are imbedded. The felspars are never fresh, but are more or less kaolinized, and not unfrequently converted into epidotes and other secondary minerals; the ferro-magnesian silicates are almost always changed into isotropic "viridite," or into various chlorites; while the titano-ferrite and magnetite have been converted either into "leucoxene" or into sulphides. The glass and microlites of the original ground-mass have in nearly all cases disappeared as the result of secondary devitrification.

The propylites are the oldest of the Tertiary lavas in the Western Isles of Scotland. They exhibit every gradation in minute structure, from holocrystalline forms (diorites) through various "granophyric" and "pilotaxitic" types into true vitreous rocks ("pitchstones"). They are found constituting lava-streams, which are usually short and bulky; eruptive bosses or "Quellkuppen"; and lenticular intrusions or "laccolites."

By carefully following in the field the much-altered rocks to points where they retain some of their original characters, the propylites can be shown to represent various interesting types of andesite and diorite. The amphibolic and micaceous rocks include hornblende-andesites, hornblende- and mica-andesites containing enstatite, diorites, and quartz-diorites. Among the pyroxenic rocks the most noticeable varieties are the labradorite-andesites, the pyroxene-andesites—of which both "trachytoid" and "vitrophyric" forms occur—as well as examples of what have been called "diallage-andesites" (the nature of the pyroxene in which was fully discussed): these rocks are found passing into augite-diorites, and quartz augite-diorites.

A microscopic study of these rocks enables us to investigate the processes by which they have acquired their peculiar characters. The chief and most widely operating cause of change is thus demonstrated to have been *solfataric action*; and this was shown to have accompanied the intrusion into the andesites of masses of igneous material of highly acid composition (granites and felsites). This solfataric action has been developed around each of the five volcanic centres described in 1874. A smaller and much more local cause of change—some of the results of which are strikingly contrasted with those of the wide-spread solfataric action—is found in the *contact-metamorphism* resulting from the intrusion into the andesites of masses of igneous rocks of basic, intermediate, or acid composition.

The much-altered propylites of Tertiary age were shown to have their exact analogues among the older (Palæozoic) lavas of Scotland and other districts. These rocks, which have been called "felstones," "porphyrites," etc., are andesitic lavas, some of which have suffered only from the action of surface-waters, while others among them must have been profoundly affected by solfataric action and converted into propylites, prior to the operation of the surface-agencies of change.

Forming a very striking contrast with the older Tertiary andesites (propylites), are the numerous scattered and generally small masses of rock which belong to a late period in the Tertiary, and constitute the youngest volcanic rocks of the British Islands. These rocks are found intersecting, in the form of dykes, the great sheets of olivine-basalt; or where poured out at the surface (as at the Sgùrr of Eigg and Beinn Hiant in Ardnamurchan), lie upon their greatly eroded surfaces. The rocks in question, which have the mineralogical constitution of augite-andesites, are remarkable for the wide variations in their aspect and chemical composition; and this was shown to result from *differences in the proportion of the crystalline and glassy constituents to one another*. Holocrystalline aggregates, of basic composition, are found passing, as the quantity of acid glass increases, into various "ophitic," "intersertal," and "pilotaxitic" types, finally assuming the "vitrophyric" form of "pitchstone-porphyries"—rocks which have a distinctly acid composition. The rocks of the Tertiary dykes in Southern Scotland and the North of England, which have been described by Dr. A. Geikie, Mr. Teall, and other authors, were shown to agree with these later Tertiary andesites, both in their mineralogical constitution and in the peculiar phases which they present to us. The latest Tertiary ejections were shown in 1874 to bear the same relations to the five grand volcanoes of the Western Isles which the chains of "puys" in Auvergne do to the great central volcanoes of that district; and this conclusion is strikingly confirmed by petrographical studies of which the results were given in the present memoir.

CORRESPONDENCE.

AGE OF THE VOLCANIC SERIES IN SHROPSHIRE.

SIR,—In reference to the debate on a paper "On the Pebidian Yoredale Series of St. Davids," read by Prof. C. Lloyd Morgan before the Geological Society on the 8th inst., Prof. Blake is reported to have said that recent work in Shropshire "had shown that there was a volcanic series more satisfactorily classed with the Cambrian than with the underlying series." Though I have some familiarity with the older rocks of Shropshire, I am unable to call to memory any volcanic series that can by any reasonable stretch of imagination be referred to the Cambrian. If Prof. Blake refers to the Uriconian system, surely the most recent work tends to throw it further back from the Cambrian. But perhaps he will favour your readers with a few words of explanation. CH. CALLAWAY.

SANDORE, WELLINGTON,
Jan. 16th, 1890.

GROUND MORAINES.

SIR,—I have just read in Professor James Geikie's Address to Section C, British Association, "Swiss geologists are agreed that the ground-moraines which clothe the bottoms of the great Alpine valleys, and extend outwards sometimes for many miles upon the low ground beyond, are of true glacial origin. Now these ground-moraines are closely similar to the Boulder-clays of this country [Britain] and Northern Europe."

We have in New Zealand, also, extensive deposits of ancient glaciers; but I have never seen in New Zealand anything corresponding to the Boulder-clays and stratified tills of Britain; and if this is correct, it would follow that Boulder-clays cannot be the ground-moraines of glaciers.

The subject is an important one, and I would suggest that the British Association should send some one to New Zealand who is an expert in Boulder-clays, to settle the question. Two months in Otago, Canterbury, and Westland, between November and April, and three months for the two voyages, would be sufficient time, and the cost would not be more than £200 or £250.

I do not know any more promising geological work at the present day than a comparison of the glacial deposits of New Zealand with those of the northern hemisphere; but to be effectual, the comparison must be made by one who is well acquainted with the northern deposits.

F. W. Hutton.

Christchurch, N. Z., 12*th Nov.* 1889.

CORAL-LIKE STRUCTURES FROM THE CULDAFF LIMESTONE, CO. DONEGAL.

Sir,—I feel sure it will interest many of your readers to learn that the peculiar Coral-like structures from the Culdaff Limestone have recently been identified by Prof. James Hall, of Albany, and Mr. Charles Walcott, of the U. S. Geological Survey, as belonging to two genera of Palæozoic Corals, namely, *Columnaria* and *Tetradium*; forms which are often found together in the Hudson Group of America. These determinations have been arrived at, first, from photographs of specimens from the Survey Collection, but afterwards from five specimens selected and forwarded for examination. The determinations were independently made, and serve to confirm each other; and Prof. Hall gives a detailed diagnosis of each specimen.

I may add that similar determinations have been arrived at by Professors Dana and Ferd. Roemer from an inspection of photographs only. Descriptions of some of these forms will appear in the Geological Survey Memoir on Inishowen, North Donegal, now passing through the press. The identification of these forms by such experienced palæontologists as those above named must be regarded as of the highest importance in throwing light on the question of the age of the Donegal crystalline rocks; a question to which I hope to return at a future time.

Edward Hull.

Geological Survey of Ireland,
14, *Hume Street, Dublin.*

NOTE ON *PHLYCTÆNIUS*, A NEW GENUS OF COCCOSTEIDÆ.

Sir,—As my friend Dr. Hinde has just called my attention to the fact that the name *Phlyctænius* has already, under the form *Phlyctænium*, been given by Prof. Zittel to a genus of fossil Sponges, I propose to substitute for it the term *Phlyctænaspis*, concerning which I can find no evidence of preoccupation.

R. H. Traquair.

RADIOLARIAN CHERT IN THE BALLANTRAE SERIES (=LLANDEILO-CARADOC) OF THE SOUTH OF SCOTLAND.

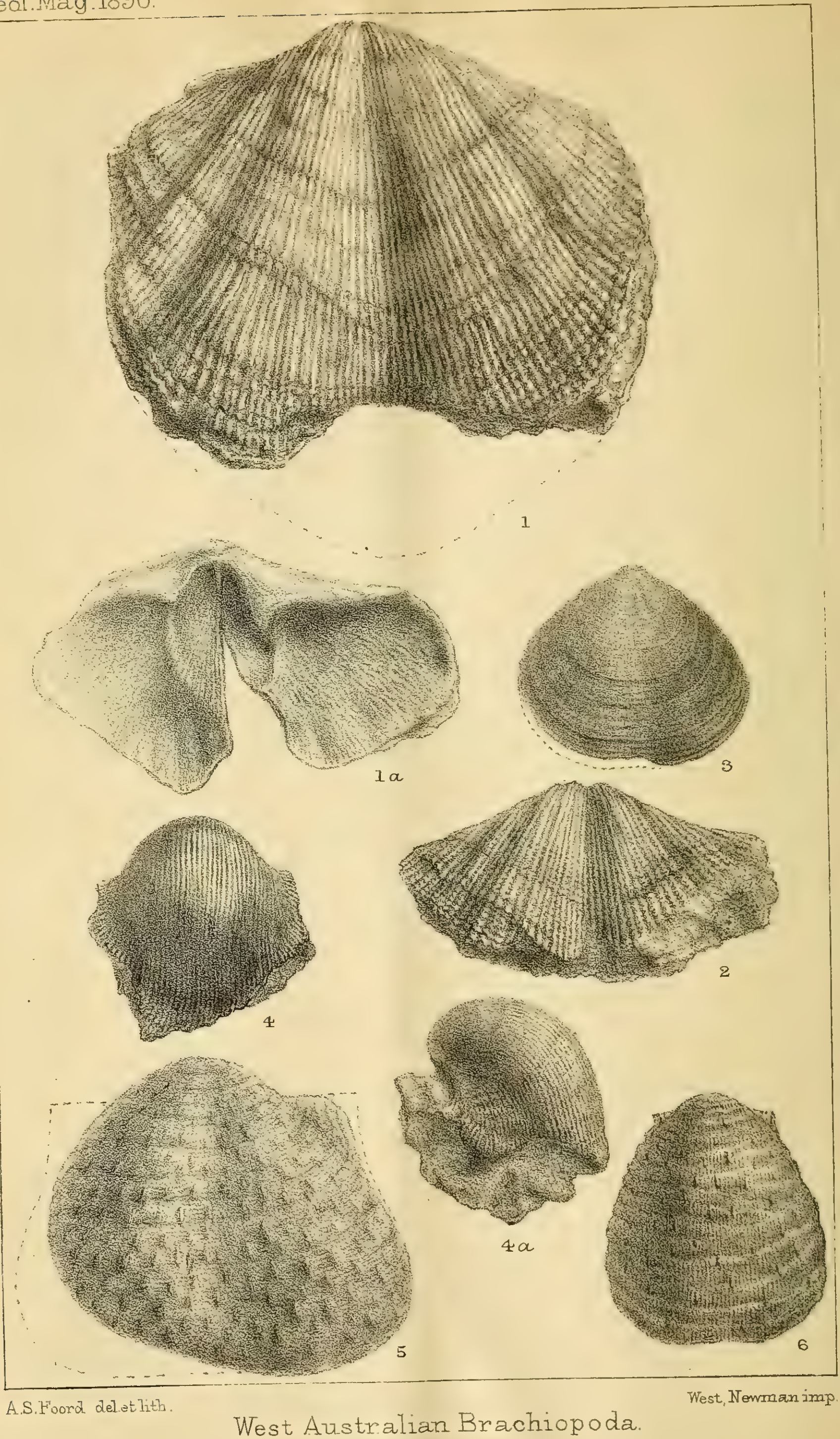
Sir,—Sections of this rock, just received from Mr. B. N. Peach, of the Geological Survey of Scotland, unmistakably show that it is mainly composed of Radiolarians. These bodies were first recognized in the chert by my friend Prof. H. A. Nicholson, but their real nature is only now conclusively shown in the sections sent me.

21 *February*, 1890.

G. J. Hinde.

A.S. Foord del. et lith. West, Newman imp.

Spirifera lata, M'Coy.
Carboniferous Sandstone, West Australia.



A. S. Foord del. et lith. West, Newman imp.

West Australian Brachiopoda.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VII.

No. IV.—APRIL, 1890.

ORIGINAL ARTICLES.

I.—Notes on the Palæontology of Western Australia.

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

[PLATES VI. and VII.]

(*Continued from the March Number*, p. 106)

Spirifera lata, M'Coy. Pl. VI.

1847. *Spirifera lata*, M'Coy, Ann. Mag. Nat. Hist. vol. xx. pp. 233, pl. xiii. fig. 7.
1877. *Spirifer latus*, de Koninck, Recherches sur les Fossiles Paléozoiques de la Nouvelles-Galles du Sud (Australie), p. 244.
1878. *Spirifera lata*, R. Etheridge, jun., Cat. Australian Fossils, p. 56.

"Transversely rhomboidal, moderately gibbose, width four times the length; sides flattened, regularly attenuating to the very acute cardinal angles; cardinal area broad, flat; mesial fold wide, defined, angular, smooth; about sixteen to eighteen slightly convex, simple, smooth ribs on each side of the mesial fold, becoming indistinct as they approach the cardinal angles, so as to leave nearly a third of the length of the sides smooth."

"This differs from the widest varieties of the *S. disjuncta*, Sow., by its defined and smooth mesial hollow, the extent of the smooth space at the end of the sides, and the smaller number and greater width of the radiating ridges, which are also much less prominent; the smoothness of the mesial fold and width of the cardinal area separate it from the *S. convoluta*, Phil.; and from the *S. Roemerianus*, de Kon., it is known by its size, greater width, smooth cardinal extremities and flatter and wider lateral ridges. Length [of the type-specimen] 1 inch 1 line, width 4 inches."

The specimens representing this species in the present Collection are crowded together in a slab of coarse, yellowish sandstone. They are all more or less covered by the matrix, but the characters of the species may easily be made out in the aggregate, and these are found to agree perfectly well with M'Coy's species.

This fine group of specimens was collected by the Hon. John Forrest, C.M.G., F.G.S., Surveyor-General and Commissioner of Crown Lands for Western Australia.

Judging from the figure, which is that of a very imperfect specimen of a ventral valve, I should say that Mr. Etheridge's *Sperifera convoluta* ? (Phil.) really belongs to the present species.[1]

[1] See Quart. Journ. Geol. Soc. vol. xxviii. 1872, appendix to R. Daintree's Geology of Queenland, by R. Etheridge, F.R.S., p. 335, pl. xvii. fig. 3.

Locality.—Lyons River, a tributary of the Gascoyne River; Western Australia,[1] in a ferruginous and slightly micaceous sandstone.

Spirifera Hardmani, sp.nov. Plate VII. Figs. 1, 1*a*.

This species is of large size, and probably a little wider than high. The width of the hinge-area is a little less than that of the shell, the cardinal angles projecting slightly beyond the former. The cardinal angles are narrowly rounded. The hinge-area, as may be seen in Fig. 1*a*, is not large. The ventral valve is divided into two slightly rounded areas by a broad, rather shallow median sinus. Three or four ill-defined folds occur on the flanks of the shell on each side of the sinus. The shell is ornamented with numerous, rather strong, radiating ribs or plications, some of which bifurcate about midway between the umbo and the inferior border; these are intersected at intervals by lines of growth, and near the margin the shell developes numerous concentric, scale-like, imbricating laminæ.

In the interior of the ventral valve (Fig. 1*a*) a strong tooth is situated on each side at the base of the fissure, but the shelly plates supporting these are almost entirely destroyed, a portion of one only (right-hand side of figure) being preserved. The remains of a short septum are seen just beneath the beak. The impression of the cardinal muscles is obliterated in the figured specimen, but it is well seen in another fragment, less perfect in other respects. The surface outside the muscular area is covered with ramifying vascular impressions.

It is a singular fact that no remains of the dorsal valve of this species have been found, though the fragments of the ventrals are very numerous.

In one of the plates of a forthcoming work on Queensland Palæontology, by Mr. Robert Etheridge, jun., now of Sydney, New South Wales, there is a fragment of a shell which is certainly identical with the present species, with which it perfectly agrees. In the explanation of the plates, communicated by Mr. Etheridge to Dr. Henry Woodward, F.R.S., the fragment in question is designated *Spirifera trigonalis* [Martin], var. *crassa* (Davidson), de Koninck? But the doubt expressed by the note of interrogation shows that the suggested name for this fragment was only given tentatively.

The occurrence of the present species in Queensland is interesting as showing its tolerably wide geographical distribution.

Spirifera Hardmani is one of the few species among the Kimberley fossils which I am able to identify with some degree of certainty with a Queensland form, a circumstance to be accounted for probably by the fragmentary condition of the specimens hitherto obtained in Queensland.

The present species finds its nearest analogue in *Spirifera cincta*, von Keyserling,[2] but it is clearly distinguished therefrom by its

[1] See a short paper by F. T. Gregory in Quart. Journ. Geol. Soc. 1861, vol. xvii. p. 475; also the paper by W. H. Hudleston, F.R.S., in the same Journal, 1883, vol. xxxix. p. 582, already referred to.

[2] Wissensch. Beobacht. auf einer Reise in das Petschoraland im Jahre 1843,

straighter hinge-line, the lesser prominence of the beak of the ventral valve, and the more quadrate form of the shell.

Locality.—Gascoyne River.

SPIRIFERA MUSAKHEYLENSIS,[1] Davidson, var. AUSTRALIS, var. nov.
Plate VII. Fig. 2, and ? Plate V. Fig. 12.

1846. *Spirifer fasciger*, von Keyserling, Wissensch. Beobacht. auf einer Reise in das Petschoraland im Jahre 1843, p. 229, Tab. viii. figs. 3, 3*a*, 3*b*.
?1860. *Spirifer tegulatus*, Trautschold, Nouv. Mém. de la Soc. Imp. des Nat. de Moscou, tom. xiii. p. 354, "Die Kalkbrüche von Mjatschkowa," Taf. xxxv. figs. *a*—*g*.
1862. *Spirifera Moosakhailensis*, Davidson, Quart. Journ. Geol. Soc. vol. xviii. p. 28, pl. ii. fig. 2, *a*—*c*.
1863. *Spirifera Moosakhailensis*, de Koninck, Fossiles Paléoz. de l'Inde, p. 34, pl. xi. figs. 2, *a*—*c* (copied from Davidson's, *loc. cit.*).
1865. *Spirifer Moosakhailensis*, von Martens, in Beyrich, Physik. Abhandl. der Königl. Akad. der Wissensch. zu Berlin (1864), Ueber eine Kohlenkalk-Fauna von Timor, p. 77, Taf. i. fig. 7.
1866. *Spirifera Moosakhailensis*, Davidson, Quart. Journ. Geol. Sec. vol. xxii. p. 41, pl. ii. fig. 5.
1887. *Spirifer Musakheylensis*, Waagen, Pal. Indica, Ser. xiii. Salt Range Fossils, vol. i. p. 512, pl. xlv.
1889. *Spirifer fasciger*, Tschernyschew, Allgem. geol. Karte von Russland, Blatt 139, (Mém. du Com. Géol. vol. iii. No. 4), pp. 353, 366, Taf. v. figs. 4, *a*—*c*.

The following is Davidson's description of this species:—"Shell transversely rhomboidal; valves almost equally deep or convex; hinge-line variable in length, sometimes not half as long as the breadth of the shell, while at times it is as long. Ventral area of moderate width; fissure wide and partially covered over by a pseudo-deltidium. Dorsal valve sub-linear; beak small and moderately incurved. In the dorsal valve there exists a wide, elevated angular fold, and in the ventral one a corresponding sinus. The whole surface of the shell is covered with numerous small ribs, which cluster into fasciculi, seven or eight being collected into groups, which give to the valves the appearance of a double plication, many of the smaller ribs being due to interpolation; while the whole surface and ribs are closely intersected by numerous sharp, projecting, concentric undulating laminæ, of which four or more may be counted in the breadth of a line. Dimensions very variable: a large example measured 26 lines in length by 39 in width and 18 or 19 in depth.

It was not until after much hesitation that I have ventured to propose a new name for the *Spirifera* under description. In external shape as well as by the grouping of the ribs it bears much resemblance to several known species of *Spirifera*, and especially to that figured in Owen's "Geol. Survey of Wisconsin and Minnesota"

p. 229, Tab. viii. figs. 2 *a*—*c* (1846). See also de Koninck, Faune du Calc. Carb. de la Belgique, 1887 (Ann. du Mus. Roy. d'Hist. Nat. de Belgique, tom. xiv.), pt. vi. p. 108, pl. xxiv. figs. 6, 7, and pl. xxvi. figs. 1—4. Recorded also by Th. Tschernyschew, Allgem. geol. Karte von Russland, Blatt 139 (Mém. du Com. Géol. vol. iii. No. 4), p. 355.

[1] This word is written "Moosakhailensis" by Davidson, but I have adopted Waagen's spelling of it (Salt Range Fossils, Pal. Ind.), as being doubtless the more correct one.

(pl. v. fig. 4) under the name of *Sp. fasciger*, Keyserling?; but I partake of that author's doubts while referring the shell in question to de Keyserling's Russian species. It approaches also by its shape to certain examples of d'Orbigny's *Sp. Condor*, *Sp. cameratus*, Hall, as well as to some exceptional British specimens of *Spirifera striata*; but in none of these do we perceive, nor does any author describe the peculiar and beautifully regular, closely disposed, sharp, projecting, concentric, undulating laminæ, which resemble so closely those of *Sp. laminosa*, and which give to the shell its beautiful sculptured appearance. *Sp. Moosakhailensis* is common in the Punjab, at Moosakhail, Chederoo, Kafir Kote, etc."

The close resemblance of the Australian fossil to *Sp. Musakheylensis*, Dav. (the types of which are now before me), is at once apparent, and the only difference between them is that the ornaments of the Australian species are perhaps a little coarser than those of the Indian one, *i.e.* the former has slightly larger and consequently fewer small ribs (comparing together individuals of the same size) than the latter, and the imbricating lamellæ exhibit the same divergence of character. It seems, however, scarcely necessary to regard these slight differences as of more than varietal importance, especially when one takes into account the variations in any large assemblage of Brachiopods, as Davidson himself has so often demonstrated in his plates.

The synonymy of the present species is somewhat involved. Taking first *Spirifer fasciger*, Keyserl., we find that it is regarded by Th. Tschernyschew,[1] who had access to the type-specimen (or specimens), as identical with *Spirifera Musakheylensis*, Dav., and with another form which he describes and figures from the Southern Urals. The following is the passage in which he gives his views concerning these forms:—"I find," he says, "no sufficient ground for separating *Spirifer tegulatus*, Trautsch., from the Indian species [*Musakheylensis*], and from *Sp. fasciger*, Keyserl." The figures of the latter in Tschernyschew's plate are certainly in no way distinguishable from those of Waagen[2] in the "Palæont. Indica." Waagen, while admitting the very close relationship between *Spirifer fasciger* and *Sp. Musakheylensis*, finds that the ornaments in the former are coarser than those of the latter. In this respect, therefore, *Sp. tegulata* approaches the present variety. Waagen also observes that "if we set aside the lamellose character of the striæ of growth, then there is quite a number of species to which the present one might be compared," and that probably *Sp. fasciger* is the ancestral type of them all.[3]

It has been seen that Davidson failed to recognize the identity of his species with *Sp. fasciger*, because von Keyserling's specimens being only casts, one at least of the most important of the specific characters was wanting in them; but he seems to have overlooked Trautschold's species, in which the lamellose, imbricated striæ are

[1] See table of synonymy.
[2] Pal. Ind.—Salt-Range Fossils, 1887, vol. i. p. 512, pl. xlv.
[3] *Loc. cit.* p. 515.

clearly figured, an enlarged figure of them being given to show their structure.[1]

If now we regard *Sp. tegulata* of Trautschold either as a distinct species, according to Waagen, or merely as a variety of *Musakheylensis*, then Davidson's name would still hold good. If, on the other hand, Tschernyschew's views are correct, viz. that *Musakheylensis* and *tegulata* are one and the same species, the latter name, being of prior date, must take the place of the former. Waagen holds very decided opinions upon this point. He says, that "the peculiar sculpturing, so similar to that of *Musakheylensis*, has been excellently described and figured by Trautschold; but from his description and figures it can also be concluded with very great certainty that the two species are different. In *Spirifer tegulatus* the radiating ribs are much coarser, and the lamellose sculpturing more strongly developed than in the Indian form, and there is apparently but little doubt that the two species are different. Nevertheless, it is highly probable that the Russian species, which occurs in the Upper Carboniferous Limestone of Moscow, is the ancestor of the Indian shells."

After much deliberation, I have thought it best to leave the matter an open question, retaining for the present Davidson's name, which is now so widely current, for the species, making the Australian form a variety of it. Most probably the fossil described by von Martens from the Island of Timur belongs to the latter, the localities of the two forms not being very remote from each other.

The interior of a ventral valve figured on Plate V. (Fig. 12) may possibly belong to the present species, but the specimen is too imperfectly preserved to be determined with certainty.

Locality.—Gascoyne River.

SYRINGOTHYRIS EXSUPERANS, de Koninck, sp.

1877. *Spirifera exsuperans*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 249, pl. xv. figs. 1, 1*a*, 1*b*.
1878. *Spirifera exsuperans*, Etheridge, jun., Cat. Australian Fossils, p. 56.

There occur in the Collection numerous fragments of the hinge-plates of this species from the Gascoyne River. Being broken in a peculiar manner, these separate pieces were very puzzling, and I at first took them to be portions of a Lamellibranch; but my friend Mr. R. B. Newton, to whom I showed them, fitted some of the pieces together, and thus demonstrated their true nature.

Locality.—Gascoyne River.

ATHYRIS MACLEAYANA, Etheridge, jun. Plate VII. Fig. 3 (and Woodcut).

1889. *Athyris Macleayana*, Etheridge, jun., Proc. Linnean Soc. New South Wales, second ser. vol. iv. pt. ii. p. 208, pl. xvii. figs. 1—5.

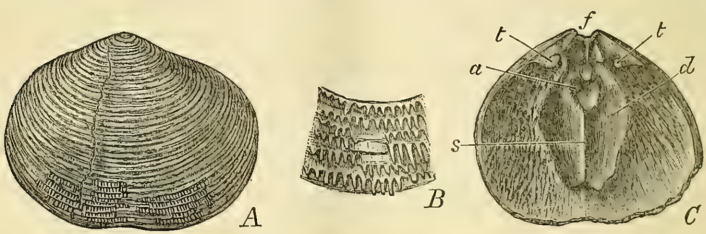
"Shell circular, or transversely oval in outline, but usually the former, plano-convex, or at times slightly concavo-convex, the ventral valve flat or slightly concave; the lateral margins are in the same plane with the hinge-line, but the front is to some extent

[1] Nouv. Mém. de la Soc. Imp. des Nat. de Moscou, 1860, tom. xiii. pl. xxxv. fig. 6*d*.

sinuated. Ventral valve flat as a rule, and very shallow, with an inconspicuous horizontal and semi-truncate umbo, but in no degree overhanging the hinge-line; foramen small, circular, opening upwards, but sometimes a little oblique; sinus very faintly shown on the surface of the valve, but indicated by a forward extension of the front margin. Dorsal valve moderately convex, evenly rounded in outline, with little or no distinction into fold and flanks; umbonal region far more marked than in the ventral valve. Surface of both valves with coarse, concentric, roughened laminæ.

"A very peculiar form of *Athyris*, from the persistent shallowness of the united valves, especially of the ventral. . . . . In one or two places the appearance of the concentric surface laminæ would lead to the belief that they projected as separate spines, after the manner of *Athyris Royssii*, Lév."

Nearly all the specimens in the Collection, with the exception of the one figured on Plate VII., are crushed, but it is plain that the valves were naturally much compressed, and none of them indicate, so far as one can judge, the amount of convexity of the dorsal valve of the specimen figured by Mr. Etheridge (*loc. cit.* figs. 3, 4). His description of this species agrees, however, so nearly with the specimens from the Gascoyne River, that I have scarcely any hesitation in referring them to it. I am fortunately enabled to give a figure of the interior of the ventral valve of the present species, which I have drawn on the wood, having succeeded in removing



Athyris Macleayana, R. Eth., jun., Carboniferous, Gascoyne River.

the matrix from one of the specimens. This supplements my brother's figure (Pl. VII. Fig. 3). Two other specimens show the interior of the same valve, and the matrix being somewhat friable, is easily cleaned out. The interior structures being thus readily laid bare will afford future collectors a valuable character for the recognition of the species. Only one of the specimens is sufficiently well preserved to show in some places the spines which ornamented the surface of the shell; in all the others these have been rubbed off, and no indication of them remains but a few faint longitudinal lines, such as are seen in Plate VII. Fig. 3, which is the external view of the same individual represented in the accompanying woodcut (*C*). In this it will be seen that the dental plates are united to the outer wall of the shell by a thick shelly callosity. The hinge-teeth (*t*, *t*) are strong and prominent, and apparently bifid. The adductor impressions (*a*) are rather deep, beginning a little below the level of the hinge-teeth, and terminating at about the mid-length of the shell, where they meet a somewhat prominent ridge or septum (*s*) which extends nearly to the front margin of the valve. This septum divides the large and spreading impressions of the cardinal muscles (*d*) into two areas which occupy nearly one-third of the interior of the valve, and terminate in two short and narrow lobes at the bottom of the septum. The rest of the interior of the shell, with the exception of a narrow marginal zone, is covered with reticulated vascular markings, strong near the hinge-teeth, and becoming less pronounced towards the front margin of the valve.

I may add that the largest individual in the Collection measures 1 inch 2 lines in length, and 1 inch 5 lines in breadth.

A single, crushed specimen, with both valves, evidently derived from a different matrix from the rest, differs slightly from them in its greater relative breadth. This example is illustrated in the Woodcut (*A*), together with a portion of its shell-ornament (*B*), consisting of flattened spines, forming a fringe at the margin of the lamellæ of which the shell is composed. A similar spiny investment covers the shell of *Athyris Roysii*, to which the present species is probably nearly allied.

Locality.—Gascoyne River.

CARBONIFEROUS FOSSILS FROM THE IRWIN RIVER, VICTORIA DISTRICT.[1]

POLYZOA.

FENESTELLA.

Fragment of the non-poriferous aspect of a frond of a species of *Fenestella*, probably *F. ampla*, Lonsdale (Strzelecki's Phys. Descr. of New South Wales and Van Diemen's Land, 1845, p. 268, pl. ix. figs. 3, *a–d*).

BRACHIOPODA.

PRODUCTUS TENUISTRIATUS, de Verneuil. Plate VII. Figs. 4, 4*a*.

1845. *Productus tenuistriatus*, de Verneuil, Géol. de la Russie d'Europe, et des Montagnes de l'Oural, vol. ii. pt. iii. Paléont. p. 260, pl. xvi. fig. 6.

1889. *Productus tenuistriatus*, Tschernyschew, Allgem. geol. Karte von Russland, Blatt 139 (Mém. du Com. Géol. vol. iii. No 4), p. 372, Taf. vi. figs. 15, *a–c*.

There are a few examples of a species which agrees in all essential points with de Verneuil's *tenuistratus*. This species differs from others of the same genus by the fineness of its striæ, their irregularity, and the absence or rarity of the tubes with which the Producti are usually provided.

The irregularity of the ribbing is referred to also by Tschernyschew as one of the distinguishing characters of *tenuistriatus*, and he adds that there are intercalated ribs between the original ones. These are quite recognizable in the specimens under description.

Locality.—Irwin River, Victoria District.

[1] An explanatory note by Mr. H. P. Woodward to the following effect accompanied these fossils:—"Irwin River, Coal Seam, a little S.E of Champion Bay, about 30 miles from coast: sandy table-land, cut through by river, exposing ferruginous sandstones and conglomerate, resting unconformably on Coal-measure Series."

Productus subquadratus, Morris. Plate VII. Fig. 5.

1845. *Productus subquadratus*, Morris, in Strzelecki's Physical Description of New South Wales and Van Diemen's Land, p. 284.
? 1847. *Productus subquadratus*, de Koninck, Mon. du Genre Productus, p. 203, Atlas, pl. xiv. figs. 1, *a–d*.
1878. *Productus subquadratus*, Etheridge, jun., Cat. Australian Foss. p. 53.
1880. *Productus subquadratus*, Etheridge, jun., Proc. Roy. Phys. Soc. Edinburgh, vol. v. p. 283.

Several tolerably well-preserved specimens are referred to this species mainly on account of the well-marked mesial furrow which distinguishes them, and is one of the chief characters in *subquadratus*.

Mr. R. Etheridge, jun. (Proc. Roy. Phys. Soc. Edinb. vol. v. 1880, p. 283), refers to de Koninck's opinion that the present species is only a form of *P. brachythærus*, G. Sow.,[1] but he does not say anything tending to confirm de Koninck's view. The specimen forming part of the Strzelecki Collection in the British Museum, and figured by Morris in Strzelecki's work on "New South Wales" (pl. xiv. fig. 4*c*, not figs. 4*a*, 4*b*),[2] assuredly cannot belong to the same species as the form named by Morris *P. subquadratus*, the type of which I have now before me. The ventral valve of the latter is extremely gibbous, and is divided into two prominent lobes by a very distinct mesial furrow, a character well displayed in Mr. H. P. Woodward's specimens. No such feature is to be found in *P. brachythærus*, nor has it apparently the numerous irregularly-disposed, conspicuous spine-bases with which the surface of *P. subquadratus* is beset. It would seem not improbable that the species doubtfully referred by Mr. Etheridge to *P. subquadratus* is, after all, not that one, because no mention is made of any mesial furrow in the description, which is so marked a character in Morris's species, and one therefore which could not possibly have been overlooked.

Locality.—Irwin River, Victoria District.

Productus undatus, Defrance. Plate VII. Fig. 6.

1826. *Productus undatus*, Defrance, Dict. des Sci. Nat. vol. xliii. p. 354.
1843. *Productus undatus*, de Koninck, Descrip. des Anim. Foss. du Terr. Carb. de Belgique, p. 156, pl. xii. figs. 2, *a—c*.
1845. *Productus undatus*, de Verneuil, Géol. de la Russie d'Europe, et les Montagnes de l'Oural, vol. ii. pt. iii. Paléont. p. 261, pl. xv. fig. 15.
1847. *Productus undatus*, de Koninck, Mon. du Genre Productus, p. 156, Atlas, pl. v. figs. 3, *a—c*.
1860. *Productus undatus*, Trautschold, Nouv. Mém. Soc. Imp. des Nat. de Moscou, tom. xiii. p. 329, Taf. xxxii. fig. 2.
1861. *Productus undatus*, Davidson, Brit. Carb. Brach. vol. ii. pt. v. p. 161, pl. xxxiv. figs. 7—13.
1877. *Productus undatus*, de Koninck, Recherches sur les Fossiles Paléozoiques de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 190, pl. ix. fig. 4.
1878. *Productus undatus*, Etheridge, jun., Cat. Australian Fossils, p. 53.

This well-marked and widely-distributed species is represented

[1] In Darwin's Geological Observations on Coral Reefs, etc. pt. ii. 1851, Appendix, p. 158.

[2] Dr. H. Woodward, F.R.S., and Mr. Etheridge, jun., proved that these figures represent "a distinct and separate species," from fig. 4*c*, which is the true *P. brachythærus* (Proc. Roy. Phys. Soc. Edinburgh, vol. v. 1880, pp. 286, 287).

by specimens which show admirably the features characteristic of it, as may be seen in the one selected for illustration. The curious crumpled appearance of the concentric wrinkles on the surface of the shell is a feature which plainly distinguishes this species from all others, and has led to its recognition in many countries.

Locality.—Irwin River, Victoria District.

SPIRIFERA MUSAKHEYLENSIS, Davidson, var. AUSTRALIS, var. nov.

A small specimen of this variety showing its characteristic ornaments.

Locality.—Irwin River, Victoria District.

SYRINGOTHYRIS EXSUPERANS, de Koninck, sp. (supra, p. 149).

Fragments of the ventral valve of this species are contained in Mr. H. P. Woodward's Collection. They are clearly identical with the specimens from the Gascoyne River. One of them shows the large area with its triangular aperture, partly closed by the pseudo-deltidium, and on the other side the ribbed shell with its deep mesial sinus.

Locality.—Irwin River, Victoria District.

RETICULARIA LINEATA, Martin, sp.

1809. *Conchilolithus Anomites lineatus*, Petrificata Derbiensia, p. 12, pl. xxxvi. fig. 3.
1836. *Spirifera lineata*, Phillips, Geol. of Yorkshire, pt. ii. p. 219, pl. x. fig. 17.
1842. *Spirifer lineatus*, de Koninck, Descr. des Anim. Foss. du Terr. Carb. de la Belgique, p. 270, pl. vi. fig. 5, pl. xvii. fig. 8.
1858. *Spirifera lineata*, Davidson, British Carb. Brach. vol. ii. pt. v. p. 62, pl. xiii. figs. 1–13.
1865. *Spirifer lineatus*, von Martens, in Beyrich, Physik. Abhandl. der Königl. Akad. der Wissensch. zu Berlin (1864), p. 76, Taf. i. figs. 13, *a–c*.
1877. *Spirifer lineatus*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 224, pl. xi. fig. 9.
1878. *Spirifera lineata*, Etheridge, jun., Cat. Australian Fossils, p 57.
1887. *Reticularia lineata*, Waagen, Mem. Geol. Surv. India—Palæont. Indica, Salt-Range Foss. vol. i. ser. xiii. p. 540, pl. xlii. figs. 6–8.

Specimens of the ventral valve of this species are recognizable in the Collection.

Locality.—Irwin River, Victoria District.

RETICULARIA CREBRISTRIA, Morris, sp.

1845. *Spirifera crebristria*, Morris, in Strzelecki's Phys. Descrip. of New South Wales and Van Diemen's Land, p. 279, pl. xv. fig. 2.
1847. *Spirifera (Reticularia) crebristria*, M'Coy, Ann. and Mag. Nat. Hist. vol. xx. p. 232.
1854. *Spirifera crebristria*, Grange, in Dumont-d'Urville's Voyage au Pole Sud, Géol. vol. ii. p. 85.
1877. *Spirifera crebristria*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 225, pl. ix. fig. 5.
1878. *Spirifera crebristria*, Etheridge, jun., Cat. Australian Fossils, p. 55.

"Shell transversely elliptical, depressed; mesial fold rather large, rounded and undefined; surface marked with numerous, fine, radiating, closely approximated striæ, crossed by the faintly prominent lines of growth; width exceeding the length by one-fourth."

(Morris). The characteristic features of this species are fairly well shown in two or three examples.

Locality.—Irwin River, Victoria District.

ORTHOTETES CRENISTRIA, Phillips, sp.

1836. *Spirifera crenistria*, Phillips, Geology of Yorkshire, pt. ii. p. 216, pl. xi. fig. 6.
1860. *Streptorhynchus crenistria*, Davidson, Brit. Carb. Brach. vol. ii. pt. v. third portion, p. 124, pl. xxvi. fig. 1, pl. xxvii. fig. 1–5 and 10 ?, pl. xxx. figs. 14–16.
1865. *Streptorhynchus crenistria* ? Beyrich, Physik. Abhandl. der Königl. Akad. der Wissensch. zu Berlin (1864), p. 82, Taf. 1, figs. 9, *a*, *b*.
1877. *Orthotetes crenistria*, de Koninck, Recherches sur les Fossiles Paléozoiques de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 212, pl. x. fig. 8.
1878. *Orthotetes crenistria*, Etheridge, jun., Cat. Australian Fossils, p. 50.

This species is represented only by a fragment of a dorsal valve.

Locality.—Irwin River, Victoria District.

LAMELLIBRANCHIATA.

PACHYDOMUS CARINATUS, Morris.

1845. *Pachydomus carinatus*, Morris, in Strzelecki's Physical Description of New South Wales and Van Diemen's Land, p. 273, pl. xi. figs. 3, 4.
1847. *Cypricardia rugulosa*, Dana, American Journ. Sci. vol. iv. p. 157.
1847. *Pachydomus carinatus*, M'Coy, Ann. Mag. Nat. Hist. vol. xx. p. 301.
„ *Mæonia carinata*, Dana, in Wilkes's Expl. Exped. 1838–42, vol. x. Geology, p. 696, Atlas, pl. vi. figs. 1*a*, 1*b*.
1877. *Pleurophorus carinatus* ?, de Koninck, Rech. sur. les Foss. Paléoz. de la Nouvelles-Galles du Sud, pt. iii. p. 283, pl. xix. fig. 8.
1878. *Pachydomus carinatus*, Etheridge, jun., Cat. Australian Fossils, p. 74.
1880. *Pachydomus* (?) *carinatus*, Etheridge, jun., Proc. Royal Phys. Soc. Edinburgh, p. 300, pl. xvi. fig. 53.

The strong umbonal ridge makes this species easily recognizable. There are two or three small examples of it.

Locality.—Irwin River, Victoria District.

Undetermined Species.

The following genera also are probably represented among the Irwin River fossils, but the specimens are too imperfect for specific identification :—*Aviculopecten*, *Modiola*, *Edmondia*, *Sanguinolites*.

GASTEROPODA.

BELLEROPHON DECUSSATUS ?, Fleming.

1828. *Bellerophon decussatus*, Fleming, British Animals, p. 328.
1844. *Bellerophon decussatus*, de Koninck, Descrip. des Animaux Foss. du Terr. Carb. de la Belgique, p. 339, pl. xxix. figs. 2, 3, pl. xxx. fig. 3.
1877. *Bellerophon decussatus*, de Koninck, Rech. sur les Foss. Paléoz. de la Nouvelles-Galles du Sud (Australie), pt. iii. p. 366.
1878. *Bellerophon decussatus*, Etheridge, jun., Cat. Australian Fossils, p. 79.

There are several examples, mostly of the young, of a shell very much like Fleming's species, but only one of them has the test remaining, and in this the ornaments are not quite satisfactorily preserved.

Locality.—Irwin River, Victoria District.

CEPHALOPODA.

Orthoceras, sp.

A small fragment half an inch long, too imperfect to determine, showing a central siphuncle and seven of the septa.

Locality.—Irwin River, Victoria District.

Discites, sp.

A young example, somewhat crushed, of the type of *Discites* [*Nautilus*] *Omalianus,* de Koninck (Descr. des Anim. Foss. du Terr. Carb. de la Belgique, Suppl., 1851, p. 711, pl. lx. figs. 3, *a–c*). The specimen has the test preserved, and its ornaments consist of fine thread-like spiral lines crossed by very numerous, close-set transverse lines; the septa moderately distant, *i.e.* about two lines apart upon the peripheral face, where the transverse diameter is four lines. The greatest diameter of the fossil is 1 inch 2 lines.

Locality.—Irwin River, Victoria District.

EXPLANATION OF PLATES VI. and VII.

PLATE VI.

A fine group of specimens of *Spirifera lata* (McCoy), in Carboniferous Sandstone from the Lyons River, a tributary of the Gascoyne River, West Australia.

PLATE VII.

Figs. 1, 1*a*.—*Spirifera Hardmani*, Foord, sp. nov. Exterior of ventral valve, and (1*a*) interior of ventral valve, showing hinge-area.

Fig. 2.—*Spirifera Musakheylensis* (Davidson), var. *Australis*, Foord, var. nov.

Fig. 3.—*Athyris Macleayana* (Etheridge, jun.), and see also woodcuts in text.

Figs. 1, 2, and 3, all from the Carboniferous of the Gascoyne River.

Figs. 4 and 4*a*.—*Productus tenuistriatus* (de Verneuil).

Fig. 5.—*Productus subquadratus* (Morris).

Fig. 6.—*Productus undatus* (Defrance).

Figs. 4, 5, and 6 all from the Carboniferous of the Irwin River, Victoria District.

II.—Physiography of the Lower Trias.

By T. Mellard Reade, C.E., F.G.S.

THE origin of the Lower Trias is evidently a question of interest to the readers of the Geological Magazine. Professor Bonney,[1] in an article, to the tone of which no exception can be taken, criticizes the view which I have ventured to put forth,[2] and very properly supports his own. It would be impossible and a waste of paper and type for me to traverse all his statements, as in many cases my reply would amount to little more than a reproduction, in a different form perhaps, of the arguments already made use of. There are, however, one or two points on which I should like to express myself, and there are some misconceptions that require clearing up.

Professor Bonney holds pretty strongly to the view that the pebbles of the Bunter have come from Scotland, and says, "I entirely fail to see any improbability in regarding the Pennine Chain as an upland which separated for a time the valleys of two

[1] Geol. Mag. Feb. 1890, pp. 52–5. [2] *Ibid*, Dec. 1889.

rivers draining the mountainous region to the north." As I have not done so in my original paper, I will now deal specifically with this notion.

The first difficulty in accepting it arises from the generally sparse distribution of the pebbles throughout the Bunter Sandstones of Lancashire and Cheshire, combined with the much greater development of conglomerate beds further South and in the Midland Counties. It is true that there are certain horizons in the Bunter of Lancashire and North Cheshire containing pebbles which have been dignified with the term "conglomerates" to distinguish them from the more prevalent homogeneous sandstones; but of genuine conglomerate, such, for instance, as may be seen at Market Drayton and Bridgnorth, there is a great absence.

Indeed, so much so is this the case that I am about to exhibit at the Liverpool Geological Society a block of conglomerate taken from a bed only nine inches thick disclosed by sewer excavations in Church Road, Walton.

If the pebbles were generally derived from the north by river transport, we should expect to find the conglomerate beds increasing in thickness and the pebbles in size in that direction. The contrary is the case.

Then as to the sand:—an inspection of the geological map of Scotland shows such a diversity of rock-structure, and there exist such lithological differences in the various areas that would have drained into these two hypothetical rivers, as to seem irreconcilable with the required travel of sand only, southwards.

To speak fairly, this is a difficulty that affects more or less any hypothesis, but it is doubly intensified on the subaerial and river theory of the origin of the Bunter Sandstones.

It will be seen that Prof. Bonney misconceives the facts in speaking of the Bunter generally as a "conglomerate." It is in Lancashire and Cheshire essentially a *sandstone*, and many of the so-called "pebble beds" do not possess a single pebble! Prof. Bonney writes from a locality where he is under the influence of "a practically unbroken pebble-bed at least thirty yards thick"; but this is in Staffordshire, and I claim the fact as being more in unison with my view of the marine origin of the Bunter than with its possible derivation from the north by river action. Such a conglomerate bed does not to my knowledge exist in the Trias anywhere between here and Scotland.

I do not know whether Prof. Bonney has read the two papers referred to on "Tidal Action." If not, he may possibly on perusal alter his views as to the efficiency of tides to move such pebbles as are found in the so-called "Pebble Beds."

There is, I know, great misconception prevailing on the subject of tidal action. The writers of geological text books, judging from all that I have read, and I have examined many, are mostly "quite at sea" on the tides, and seek to confine their effects to the shore! Prof. Bonney asks, "Is there any evidence that these currents would be capable of sweeping about pebbles 3 or 4 inches in diameter?"

to which I answer, "Yes, plenty," but also add that such a size is not common in the Bunter of Lancashire and Cheshire.

According to the experiments of Mr. Blackwell,[1] made in a trough of elm 60 feet long, 4 feet wide, and 3 feet deep, set horizontally, a current of water having a velocity of from 105 to 125 feet per minute, started a boulder weighing 11·87 ozs., and with a current of from 165 to 180 feet it was carried along at the rate of 90 feet per minute. These velocities, the lowest about a knot per hour, and the highest rather less than two knots, are, as I have shown, frequently exceeded by tidal currents, and the size of the boulder in question is far above the mean of those of the Pebble Beds.

Captain Beechy, who investigated the tides of the Irish Sea, says of the tide entering the North Channel, "The *main body* sweeps to south by east, taking mainly the general direction of the Channel, but pressing more heavily on the Wigtonshire coast; *off which it has scooped out a remarkable ditch upwards of* 20 *miles long by about a mile only in width, in which the depth is from* 400 *to* 600 *feet greater than the general level of the bottom about it.*" Again, between Glas Island and Sqeir-i-Noe, in the Little Minch off the west coast of Scotland, the flood-stream often takes the buoys of the long lines down; "and it is a remarkable circumstance indicative of the great depth of the tidal stream here, that the buoys, though anchored in 70 or 80 fathoms, are taken completely to the bottom; star-fish and other marine animals being found attached to them."[2] These instances might be multiplied, but there are evidences of strong currents at much greater depths in the ocean; for instance, while laying the Falmouth Cable near Gibraltar at 500 fathoms, "the wire was ground like the edge of a razor, and we had to abandon it and lay a cable well in shore."[3] These facts will be found fully detailed in a paper on "Tidal Action as a Geological Cause" (Proceedings of Liverpool Geol. Soc. 1873–4), and "Tidal Action as an Agent of Geological Change," Phil. Mag. May, 1888.[4]

One of the characteristics of the pebbles of the Bunter is their extreme smoothness and roundness, and I venture to suggest that the rolling about by tidal action from day to day amongst siliceous sand, together with the wash of sand over and against them, would produce more efficacious polishing and give more travel than even the longest river we may postulate. But it is not to be assumed that all the pebbles were polished in deep water; for if the beds are marine in origin, littoral deposition and wave action are not excluded.

I think I have now answered the most material parts of Professor Bonney's useful criticisms, and as I have no personal observations to record on the Nagelflue and Molasse, to which he compares the Bunter, I must refrain from any observations thereon.

[1] These were made for the Referees of the Metropolitan Drainage.

[2] Sailing Directions for the West Coast and Islands of Scotland, from the Mull of Cantyre to Cape Wrath, p. 119.

[3] Extract from letter from Sir Jas. Anderson to the writer.

[4] See Mr. Arthur Hunt's letter on "Tidal Action," *infra*, p. 191.—Edit. Geol. Mag.

III.—On a New Species of Pycnodont Fish (*Mesodon Damoni*) from the Portland Oolite.

By A. Smith Woodward, F.G.S., F.Z.S.

THE Fossil Fishes of the English Portlandian Formation are as yet almost unknown, and every small contribution to the subject is thus of interest. *Ischyodus Townsendi*,[1] *Microdon pagoda*,[2] the partially described *Caturus angustus*,[3] an undetermined species of *Thrissops*,[4] and an undescribed species of *Mesodon*,[5] appear to be the only forms hitherto recorded; and to these may be added a large bony fish allied to *Ditaxiodus*, represented by jaws in the British Museum.

The species of *Thrissops* and the isolated jaws just mentioned require longer study and more detailed comparison than the present writer has yet been able to undertake for their satisfactory determination; but the dentition of *Mesodon* seems to be so common and typical a fossil of the Portland Beds, exhibiting such well-marked characters, that it will be convenient at once to apply to the fish it represents a defined specific name. Mandibular rami with teeth of the form here referred to have been recorded in error under the name of "*Pycnodus Bucklandi*, Ag."; and a figure of one fine specimen, now in the British Museum, is given in the Supplement to Mr. Robert Damon's "Geology of Weymouth," pl. viii. fig. 9. This fossil is a left splenial bone, showing nearly all the teeth in position, and its principal characters are repeated in five other specimens in the same collection.

The bone in question is comparatively short and broad; and the teeth of the principal series are transversely elongated, not less than twice as broad as long. These teeth are regularly arranged, with narrow interspaces, and the outer extremity of each is somewhat broader and more truncated than the inner extremity, which exhibits a slight tendency towards tapering. The inner series of rounded teeth is relatively larger than usual in the genus, and is irregularly spaced; while still nearer the inner border are five smaller round teeth, with no definite regular arrangement. The outer teeth are smaller than those of the principal inner row, and seem to be disposed in three close but indefinite series, with a trace of a fourth marginal series; they vary in size and form indiscriminately, some being imperfectly hemispherical and others transversely elongated; and none exhibit a direct linear arrangement, although the median of the three series is marked by its teeth being of slightly less size than those of the other two. In another specimen the fourth or outer marginal series

[1] Sir Philip Egerton, Proc. Geol. Soc., vol. iv. (1843), p. 156. E. T. Newton, Chimæroid Fishes, Brit. Cret. Rocks (Mem. Geol. Survey, 1878), p. 33, pl. xi.

[2] Smith Woodward, Geol. Mag. [3] Vol. VI. (1889), p. 454. *Pycnodus pagoda*, J. F. Blake, Quart. Journ. Geol. Soc., vol. xxxvi. (1880), p. 228, pl. x. fig. 10.

[3] L. Agassiz, Poiss. Foss., vol. ii. pt. ii. (1843), p. 115.

[4] Smith Woodward, Geol. Mag. [3] Vol. VI. (1889), p. 455.

[5] Woodward and Sherborn, Cat. Brit. Foss. Vertebrata (1890), p. 121. *Pycnodus Bucklandi*, J. F. Blake (*non* Agassiz), Quart. Journ. Geol. Soc., vol. xxxvi. (1880), p. 227, and R. Damon, Geol. Weymouth (1860–88), Suppl., pl. viii. fig. 9.

is observed to extend along the posterior half of the bone, disappearing in the anterior half.

On comparing this form of dentition with that from the Lower Oolites named *Pycnodus didymus*, Ag.—which is most probably the lower jaw of *Mesodon Bucklandi*—it will be seen that the Portland fossil is distinguished (i.) by having the inner series of teeth relatively larger, (ii.) by exhibiting part of a supplementary inner row, and (iii.) by displaying the outer small teeth in three series, with half of a fourth series, all very irregularly arranged. Such differences may certainly be regarded as of specific value; and these characters also appear to separate the present fossil from all other jaws of *Mesodon* hitherto described. The most nearly related form is *Mesodon Nicoleti* (Ag.), from the Portlandian of Soleure, Switzerland. This species, however, is not satisfactorily defined, being apparently founded on an imperfect mandibular ramus with abnormally developed outer teeth; and if certain specimens in the British Museum, obtained from Soleure and probably referable to *M. Nicoleti*, are correctly so determined, the specific distinctness of the Swiss form from the English fossil is shown (i.) by the relatively smaller size of its inner teeth, (ii.) by the absence in it of a partial supplementary series inside and of a fourth series outside, and (iii.) by the greater regularity in the arrangement of its three rows of outer teeth.

Under the circumstances, the *Mesodon* of the English Portlandian may appropriately receive the name of *M. Damoni*, in memory of one of the most successful explorers of that formation, who first made known the fossil jaw by publishing a good figure.

IV.—On *Cœlacanthus Phillipsii*, Agassiz.

By James W. Davis, F.G.S., F.L.S.

The late Prof. Louis Agassiz, whilst on a visit to Halifax with Prof. John Phillips, during the years in which he was preparing his "Recherches sur les Poissons fossiles," identified the caudal extremity of a large species of Cœlacanth fish to which he appended the name of *Cœlacanthus Phillipsii* in honour of his friend. The specimen is from a large "baum-pot," as the calcareous nodules are locally termed, obtained from the Lower Coal-measures. This specimen was found at the Swan Bank Pit at Halifax, and, so far as I know, is the only one which has been discovered. The surface exposed by splitting the nodule is 0·295 m. diameter, and the part of the fish preserved extends across it; it consists of the caudal portion of a large individual, which, had it been perfectly preserved, would have been between four and five feet in length. The vertebral axis extended in a straight line across the surface: its constituent parts are not preserved, but the distance between the neural and hæmal spines indicates a vertebral column of considerable size and power. Attached to the vertebral column are about thirty rays above, and a similar number below, which will probably indicate the same number of vertebral segments. The first caudal fin is supported by neural and hæmal spines, interspinous bones, and fin-rays. The spines at a distance of 0·160 m. from the extremity of the anterior fin have a length of 0·050 m.; further back they decrease in length, and extend at a more acute angle with the axis of the body. The proximal end of each spine is bifurcated and broadly expanded for attachment to the cartilaginous column; the distal extremity is clavate with a flattened extremity. The proximal extremities of the interspinous bones are similarly clavate, and the flattened ends of each were joined together by a cartilaginous envelope. The interspinous bones apparently thin out to a point in the opposite direction, and the method of their attachment to the rays is not very clear. The rays do not afford any evidence of the bifurcated extremity embracing the interspinous bones, described by Agassiz as pertaining to *C. granulosus*, but appear rather to form a sort of splice with it. The fin-rays are articulated, and repeatedly bifurcate; their distal extremities are fine and slender. The posterior part of the tail, as represented in this specimen, somewhat disturbed and imperfect, indicates a breadth of 0·160 m. The second expansion of the caudal fin is not represented. A number of neural and hæmal rays occupy the space between the origin of those supporting the tail and the margin of the baum-pot; they are long and slender and deeply bifurcated for attachment to the vertebral axis; and the rays are hollow, but to a less extent than those of *Cœlacanthus Tingleyensis*, Davis,[1] which, however, are thicker in comparison to their length than are these. Agassiz remarks that the caudal fin is rounder than in *Cœlacanthus granulosus*, Agass.;[2] but it is more than probable that the round appearance of this specimen is due to its imperfect preservation.

A large number of scales are preserved; those on the anterior part are 0·100 m. in diameter, more or less circular behind, and ornamented with raised lines of enamel where the external surface is exposed. Most of the scales, however, are seen from the under side, as the result of the manner in which the nodule has split, and these exhibit a series of concentric lines parallel with their posterior border. Amongst the scales are two or three dissociated plates 0·30 m. across, which are exposed on the under side, and covered with concentric lines similarly to the smaller scales. The extension of the vertebral axis posteriorly between and beyond the lobes of the caudal fin is enveloped in smaller scales similar to those further forward, but only about half the size. There is no trace of other fins than the caudal.

Otto M. Reis, in a recently published memoir on "Die Cœlacanthinen,"[3] has separated from the genus *Cœlacanthus* all those species with striated scales which occur in the Coal-measures; retaining those from the Permian formations, with *Cœlacanthus granulosus* (non *granulatus*), Agass., and *C. Hassiæ*, Münst., as types, and with them *C. caudalis*, Eg., and *C. elongatus*, Huxley. The species excluded, viz. *C. lepturus*, Ag., *C. elegans*, Newb., *C. ornatus*, Newb.,

[1] Trans. Linn. Soc. vol. ii. p. 427. [2] Poiss. foss. vol. ii. p. 172, pl. xlii.
[3] Palæontographica, vol. xxxv. 1888.

C. robustus, Newb., *C. Phillipsii*, Ag., *C. Huxleyii*, Traq., and *C. Tingleyensis*, Davis, are transferred to a new genus, *Rhabdoderma*. After a careful comparison of the species now described with the typical *C. granulosus* figured by Agassiz, there does not appear any generic difference in them to warrant such a separation.

The Halifax Hard-bed Coal rests on the Ganister rock and Seat earth used for making fire-bricks; it is an impure Coal containing iron in the form of pyrites, and not unfrequently nodules of the same substance. Rounded concretions containing carbonate of lime are also found in the Coal. Both contain vegetable remains in a beautiful state of preservation; when cut for microscopical examination, minute details of structure are exhibited with marvellous fidelity. Immediately above the Hard-bed Coal is a stratum of laminated shale, which is in some localities almost entirely composed of the fossil shells of marine genera, including a large proportion of *Aviculopecten*. The bed is about four inches in thickness; above, it is succeeded by a bed of shale four to six feet thick, containing a considerable number of nodular concretions, composed of carbonate of lime, with an outer covering of iron pyrites. These when broken are found to contain great numbers of remains of mollusca of the marine genera *Goniatites*, *Nautilus*, *Bellerophon*, *Orthoceras*, *Nucula*, *Aviculopecten*, and others less common. Fossil fish remains are also found associated, and it is in one of these balls that the example of *Cœlacanthus Phillipsii* was found. Scattered over the surface of the nodule are shells of *Goniatites*. From its association with these marine mollusca there appears to be no doubt that *Cœlacanthus* existed in salt-water during the formation of the Lowest Coal-measures. This is interesting for comparison with *C. Tingleyensis*, Davis, found in the Cannel Coal at Tingley, which is in the Middle Coal-measures. The Cannel Coal was deposited in a series of lake-like lagoons, the bottom of which were filled with fresh-water bivalves of the genus *Anthracosia*. The remains of *Cœlacanthus* occur in great abundance, and it lived at this time in fresh-water. The specimen of *C. granulosus*, Agass., was obtained from the Magnesian Limestone of East Thickley, in Durham, which is of marine origin.

V.—On the Schists of the Lizard District.

By Alexander Somervail, Esq.

Introduction.

THIS paper is intended as preliminary to one shortly to follow on the nature and origin of the banded structure in these rocks.

I have deemed it necessary to treat of the present subject as introductory to the other, giving my own views as to what I believe to be the true origin and relations of these rocks to each other, as these seemed to me to have a very direct and important bearing on the question of their banded structures.

Under the term schists used in the title I include all the rocks composing the "granulitic," "hornblendic" and "talco-micaceous" groups of Prof. Bonney, F.R.S., and Sir H. De la Beche. Although separated into this triple division, I quite agree with the Professor that these "form but one series." I cannot, however, regard them as forming a strictly ascending or descending series in the order enumerated; neither am I certain that one of the groups, the "talco-micaceous," can any longer be regarded as a separate and independent group in itself for reasons to follow.

I shall briefly notice the leading petrological characters of each group of rocks, referring the reader to the elaborate descriptions of Prof. Bonney[1] and Mr. J. J. H. Teall,[2] M.A., F.G.S., for minute information.

I. The Granulitic Group.

This group was founded by Prof. Bonney to receive certain rocks held by him to form the uppermost of the three series, and composed "of greyish granitoid rocks, composed mainly of quartz and felspar, sometimes almost a quartzite, sometimes almost simulating a vein-granite, associated with more hornblendic, chloritic, earthy and micaceous layers."

These "granulitic" rocks throughout the entire extent of the area certainly form a very large variety, ranging from a rock scarcely discernible from an ordinary granite, to dark compact diorites, the latter frequently highly porphyritic. There are also quartzo-felspathic varieties in which one or other mineral predominates, sometimes with the addition of hornblende in variable quantities. Other varieties consist simply of pure felspar, or nearly so, from a granular, to a fine homogeneous texture. These might be classified under granites, granulites, tonalites, quartz-diorites, and diorites. Nearly all of these varieties occur in more or less extensive or isolated masses, and frequently pass by transition into each other. They also occur in many areas of the district interbanded together, aptly described by Mr. Teall as the "crystalline banded series."

II. The Hornblendic Group.

These rocks for the most part consist of dark hornblende schists and more compact varieties of rock resembling diorites with a complete transition between both. A porphyritic structure more or less abounds in certain areas throughout both the rocks and schists. In the latter, as would be inferred, this structure frequently exhibits the effects of crushing.

Besides these normal hornblendic rocks, which form the bulk of this group, there are, however, many other varieties associated with them, such as mica-schists, felsitic-like-rock, quartzose and quartzo-felspathic varieties approaching the granulitic type. Although these are certainly very subordinate, yet they must be taken into account in dealing with the origin and relations of these rocks as a whole.

Mr. Howard Fox, F.G.S., was, I believe, the first to discover mica-schists (resembling those at Polpeor Cove) in the very heart of the hornblende area at Pen Olver, Trecrobin and Polledan. These mica-schists, which have been carefully measured and

[1] Q.J.G.S. vol. xxxiii. p. 884; vol. xxxix. p. 1. [2] British Petrology.

mapped by him, are in beds of considerable thickness, and occur on several horizons in the hornblende-schists.

There is also the felsitic-like-rock at Housel Cove,[1] described by myself as an altered hornblende-schist, but which, I meant to have added, might have been the original rock in a more or less altered form, out of which the hornblende-schist had been made.

Still further, among the dark hornblendes of Pradnack we find quartzose and quartzo-felspathic varieties, and even a rock approaching the granulitic type south of the serpentine junction near Rynian. There are also small bands of felspar and quartzo-felspathic matter in the hornblende-schist at the landing-place in Landewednack Church Cove, which, however limited in extent and thickness, have yet their own bearing.

All these rocks are more or less connected by a passage into each other, and the whole in turn pass into the rocks of the "granulitic" group, from which they cannot be separated.

III. Talco-Micaceous Group.

This group of rocks was originally described by Mr. Majendie,[2] Dr. Boase[3] and De la Beche,[4] and is principally confined to the extreme south-west coast between Polpeor Cove and Caerthillian; a line between these two localities drawn inland being represented on the Survey Map as the boundary separating this group from the hornblendic.

With the addition of the outlying rocks described by Messrs. Teall and Fox,[5] which are certainly connected with those of the mainland, this group seems to me to be nothing more than the mere altered states of the two former groups, the "granulitic" and "hornblendic." The rocks which compose it, in their less altered conditions are essentially on the one side those of the quartzo-felspathic or "granulitic" type, and on the other, those of the "hornblendic." It is quite true that there are rocks differing widely from both, such as the mica-schists, mica-diorites, actinolitic-schists, chlorite-schists, etc.; but if these can be shown to be but an altered form of the "hornblende" group—as I think it can—it will simplify very much the geology of this complicated area.

Again, all the above-mentioned rocks, along with intermingled masses of less altered hornblende, are seen to shade into each other in the most perfect manner, almost in every locality in this area a passage being noted from one to another. There is sometimes a transition from the compact hornblende to the greenish schist, as seen near, or between Pentreath Beach and Caerthillian, other examples extending as far as Polpeor Cove; passages from the hornblende into chlorite-schist as at the Crane, from the former rock into actinolitic-schist at the Lizard Head, and into mica-dioritic, and this into mica-schist, at the same and many other localities.

1 Geol. Mag. Decade III. Vol. VI. p. 114 (1889).
2 Trans. Geol. Soc. of Cornwall, vol. i. p. 34 (1818).
3 Trans. Geol. Soc. of Cornwall, vol. iv. p. 341 (1832).
4 Report Com. Devon, etc. p. 29 (1839).
5 Quart. Journ. Geol. Soc. vol. xliv. p. 309.

There are also as good evidences to show that these rocks—if they do not pass directly into—form part and parcel with those at the base of the Lizard Head, and the outlying rocks, which may well be claimed as granulitic, the whole having in my opinion a common age and origin, although differing widely in their lithological aspects. A transition, however, can be noted between the greenish or actinolitic-schist and the hornblende, and hornblendic, and granulitic gneissic rocks of the reefs. Many such like transitions have been noted and described by Messrs. Teall and Fox in their joint paper already referred to.

To my mind it seems quite clear that these "talco-micaceous" rocks have no separate existence apart by themselves, but are for the most part formed out of the "hornblende" series, by severe mechanical pressure and accompanying chemical change. Mr. Teall[1] has most correctly described this very area as a zone of intense dynamic metamorphism, and I think it is almost impossible for any observer not to note the fact, that here, more than in any other portion of the district, the original structure, texture and mineral constituents of these rocks have been wholly changed and replaced by secondary products to a very high degree.

The argument of their distinctness as a group drawn from their infra-position to the "hornblendic" and "granulitic" rocks,[2] is, I think, quite fallacious, as this is based on their treatment as a stratified series of deposits having an ascending rise from south-west to north-east, which however is only a system of divisional and cleavage planes, from which neither the true thickness, nor yet the true positions of the several masses of rock can be correctly estimated.

Provisionally, then, we shall take for granted the non-existence of the talco-micaceous group, regarding it meanwhile as but altered portions of the two former, which, right or wrong, will not however materially affect the points at issue in this paper.

IV. Origin of the Granulitic and Hornblende Groups.

As to the correct nature and origin of the rocks making up these two groups, there is considerable diversity of opinion.

Prof. Bonney[3] in his subsequent and modified views is still inclined to regard considerable portions of the rocks in each group as of sedimentary origin.

Mr. Teall inclines to similar opinions, but seems to restrict those rocks which he believes to be of sedimentary origin to a much smaller compass than is done by the former observer.

General McMahon,[4] F.G.S., in his recent able contribution to this subject, expresses the opinion that a certain portion, or portions of each group is made up of volcanic ashes and lavas.

If I may here venture an opinion of my own as to the exact mode of origin of these rocks, it is that there are no true tuffs or lavas, but that the whole are essentially rocks of plutonic origin. This

[1] Notes on the Lizard, from the Long Excursion of the Geologists' Assoc. for 1887.
[2] Quart. Journ. Geol. Soc. vol. xxxix. p. 5.
[3] Q.J.G.S. vol. xlv. p. 543.
[4] Q.J.G.S. vol. xlv. p. 519.

opinion is entirely based on field observations, and on the macroscopic aspects of the rocks, and also on the absence of any positive proof as yet furnished by the microscopists to lead to an opposite conclusion.

V. Relations between the two Groups.

There is also considerable diversity of opinion prevailing with regard to the relations between both groups, and the rocks which compose each, especially the rocks making up the "granulitic."

General McMahon in his paper referred to speaks of the "granulitic" group as containing many intrusive rocks, injected at different times, such as ordinary diorites, also a later porphyritic diorite, and still later veins of granite which traverse the whole.

It seems to me that if we were to eliminate both from the "hornblende" and "granulitic" groups these injected diorites and granite veins, we would almost, if not altogether, remove the whole of the rocks composing them. The porphyritic structure even in the hornblende group is much more common than was suspected, and I think it is by no means certain that there is any distinction in points of origin and age between the porphyritic and non-porphyritic varieties, even in both of the groups. Neither do I think it certain that the so-called granite vein portion of the "granulitic" group, such as we see at Kennack and elsewhere, has had a distinct and separate origin from the diorites.

Mention of the fact has already been made that the rocks making up the "hornblende" and "granulitic" groups vary from a diorite to one of granitic type, but between these two extremes there are however other rocks of an intermediate nature forming what I regard as a transition between both of these extremes, and associated with them in such a way as to bind them together into one natural group, having a common age and origin.

There are certainly areas, such as the foreshore of Kennack Cove, which might be selected as proof of the intrusion of the granite-like rock into the diorite; but, even here, it can equally well be read in the reverse way, so confusedly mingled together are these two varieties of rocks, and so often do they alternate with each other. As soon however as we leave the foreshore for the cliff of serpentine, we find both of these rocks combined together in varying proportions thrust through it. Not only is this so in several of the dykes in the Kennack area, but in many dykes throughout the whole of the Lizard district. In the dykes these rocks are so mixed up and banded together that some other explanation than their separate intrusions must be sought for. In my opinion this explanation is found in the separation of the basic and acidic portions of the magma while in the act of cooling, as pointed out in my short paper on the North Pentreath dyke;[1] or it may be the case that, during the eruption of these rocks, acidic and basic magmas were being simultaneously belched forth together, preserving a partial separation; but, as we shall presently see, there

[1] Geol. Mag. Decade III. Vol. V. p. 553 (1888).

seems good reason for supposing that the one magma may have contained within itself the elements of the whole, which became ultimately more or less differentiated.

In many instances, as at West Kennack Cove, the highly interesting and instructive Kildown Cove, and other localities, there are rocks quite intermediate in character and composition between the granitic and dioritic types. These rocks are in close juxtaposition to both granite and diorite, and decidedly form a portion of them, the whole rising together through the adjoining serpentine. These intermediate rocks frequently form great homogeneous masses without any intermingling of other varieties, or without any banded structure whatever. They are only semi-granitic or granular in texture, and in composition contain hornblende, quartz, felspar, and perhaps a little mica; yet they are neither granites nor diorites proper: still, from this stage, we can trace them into both, also into varieties with a well-defined banded structure, in which sometimes the granitic and sometimes the dioritic constituents predominate.

Such intermediate varieties of rock are frequently found both on the coast and in inland directions rising through the serpentine. A dyke of this description, cutting through the serpentine, occurs at Trelease Moor, from which might be collected several distinct varieties of rock, ranging between the granitic and dioritic types. On the coast, as immediately east of the Yellow Carn and at many other localities, there are groups of dykes close together penetrating the serpentine, which I believe to be all related, which likewise vary from the dark compact dioritic type to the "granulitic" or granitic variety.

At Kildown Cove, near the centre of the "granulitic" mass which there appears to me to cut the serpentine, is a rudely circular and concretionary-like nodule, made up of concentric layers of alternating "granulitic" and dioritic rock, with a central nucleus of granitic material, in which are also patches of hornblende. The teaching of this singular and instructive complex nodular mass appears to me not only to have a very decided and direct bearing, not only on the origin and relations of these "granulitic" and "hornblendic" rocks, but also on the origin of these banded structures.

The important question now arises, are these "granulitic" or granitic and dioritic dykes portions of the great masses representing these two groups? My own observations incline me to reply that they are, for the following reasons:—

1st. The similarity, if not the exact identity, between the rocks composing the dykes and those forming the two groups proper.

2nd. The apparent connexion between the dykes and large masses of admitted granulitic and hornblendic rocks which seem to be their feeders.

3rd. The entire absence of these, or similar true eruptive[1] dykes, cutting the massive portions of either of the two groups,[2] which we

[1] The dykes in the outer rocks off the Lizard Head seem to me to be segregation dykes.
[2] Attention to this has been drawn by Mr. Teall.

might reasonably have expected to find, had the dykes been a separate and later product.

When we come to examine these "granulitic" and "hornblendic" rocks in their massive conditions and relations, and not confined to mere dykes or small exposures, then we have more light thrown upon them. We find them both in isolated and associated masses of great extent, and if we were able to trace them fully out in a seaward direction, they would seem to completely encircle the entire area of the serpentine and gabbro.

The "granulitic" portion can now no longer be regarded as confined to the east coast, as stated by Prof. Bonney, but is more or less extensive with nearly every portion of the entire coast-line. It forms the rocks all round the base of the Lizard Head.[1] It occurs at North Caerthillian, Holestrow, in great force at and near George's Cove, and also sparingly so at other localities.

The great extent of the dark hornblende schists exposed on the south coast is clearly connected with the "granulitic" at either extremity, and also to a small extent on the south where the schists approach the serpentine. We find a connection between the dark hornblende-schists and the typical "granulitic" on the east at a little cove south of the Lower Balk Serpentine Quarry, where we are able to trace the transition between both. On the west we are able to trace the same relations at Caerthillian, and at George's Cove the dark hornblende-schists or rocks are distinctly traceable by a gradual transition into the typical "granulitic," which occurs there in considerable force. On the east coast, as at Carnbarrow and Cadgwith, the typical hornblende-schists may be seen passing into the "granulitic" rocks, an excellent example being the fine section on the portion of the cliff between the Frying-pan and Cadgwith, which here clearly shows the very gradual transition of the one group into the other.

Altogether I think that the gist of the whole evidence is clearly to prove that both groups have had a common origin, and that the granulitic or granitic portion is not intrusive in the dioritic, or *vice versa*, but that both are part and parcel of the same magma. Subsequently these rocks may, and indeed have been deformed, and crushed up together, as at the Lizard Head, and other localities, but even here, with all the intricate confusion and alterations in their mineral aspects arising from this crushing and deforming process, the relations existing between these rocks show I think no indications of intrusion.

General McMahon[2] in his paper has certainly called attention to one instance of intrusion into the granulitic. He says, p. 533, "One of the intrusive diorites is well seen at Polbarrow, where a broad dyke of it cuts right across the 'granulitic' group between the ruined boat-house and the cliff. Down below veins of it may seen intruding into the granulitic."

[1] These rocks appear to me to have a decided claim to be ranked as portions of the "granulitic" group.

[2] Quart. Journn. Geol. Soc. vol. xlv.

This statement I must confess is rather fatal to my own views; but before forming a final opinion, I should like again to revisit this locality, as I cannot but think that the General may possibly have mis-read the section.

There is another example of the intrusion of a porphyritic diabase in the talco-micaceous group at Polpeor, first noted by Prof. Bonney,[1] and also referred to by General McMahon,[2] as follows: "The eruptive character of this rock is undoubted. At low-water during spring-tides, the reefs outside the island at Polpeor are exposed for about a mile from the shore. The porphyritic diorite may be seen in these reefs cutting right across the strike of the gneiss. Nearer land it is an intruder in the green schists, generally following their bedding, but constantly shifting from one horizon to another; whilst in the cliffs of the mainland it frequently shows itself at a still higher horizon among the micaceous and hornblendic-schists."

Prof. Bonney has certainly described this porphyritic diabase, or diorite as a true intrusive dyke, and the above quotation lends it all necessary support. When it was first pointed out to me by Mr. Howard Fox, I could not then and cannot yet separate it from the other hornblendic rocks or schists exposed there, as it seemed to me to form only a portion of these, but in a much less crushed condition. I afterwards had the pleasure of finding that Mr. Teall had previously expressed the same views in his notes for the "long excursion" of the Geologists' Association for 1887.

The relations as to the upper and lower position of these two groups is, I think, rather a difficult question. Prof. Bonney, who dealt with this matter on stratigraphical grounds, referred the "granulitic" to the uppermost position; but there seem to me good reasons for nearly reversing this conclusion, or at least modifying it to a considerable extent. There is the actual evidence of rocks with as good a claim as any to be regarded as "granulitic," holding the infra-position, which may be seen by boat in sailing round the Lizard Head, where this group is found supporting the hornblende-schists. This infra-position, however, I believe to be somewhat irregular, and to be regulated by certain circumstances, although on the whole I am inclined to regard the hornblende as the upper and outer margins of the same magma out of which both have been formed.

VI. Concluding Remarks.

I cannot conclude this paper without remarking that none of the views therein are held dogmatically, and expressing the hope that former observers will renew their attention, and fresh ones take up the investigation of this complicated, yet interesting area. The difficulties are great, among which is the origin of the banded structure, in the rocks herein dealt with, which in my next paper I shall try to explain on the grounds of segregation, arising from, or taking place during the cooling of the common magma out of which all these rocks seem to me to have been formed.

[1] Quart. Journ. Geol. Soc. vol. xxxix. p. 4.
[2] Quart. Journ. Geol. Soc. vol. xlv. p. 534.

NOTICES OF MEMOIRS.

I.—New Species of Fossil Sponges from the Siluro-Cambrian at Little Metis on the Lower St. Lawrence. By Sir J. William Dawson, LL.D., F.R.S. (Including Notes on the Specimens by Dr. G. J. Hinde.) Transactions of the Royal Society of Canada, vol. vii. section iv. 1889, pp. 31–55, pl. iii. and 27 figs.

In some black shales, belonging to the Quebec Group of Logan, exposed on the shores of the Lower St. Lawrence, Sir W. Dawson discovered some thin bands, largely filled with sponge-remains. In some instances the general form and outlines of the sponges have been preserved in a compressed condition, but more often the thin beds consist of a mass of spicules irregularly commingled together. In all cases the original siliceous structure of the spicules has disappeared, and they are now composed of pyrites. The sponges appear to belong almost exclusively to the Hexactinellidæ; the genus *Protospongia* is represented by six new species, *Cyathospongia* (*Cyathophycus*), Walcott, by one species, and *Hyalostelia* one species. A new genus, *Acanthodictya*, is proposed for cylindrical sponges with a dense fringe of spicular rays on the exterior, and some small oval sponges, in part at least apparently composed of simple acerate spicules, are placed in the new genus *Lasiothrix*. The specimens of *Protospongia* are more complete and better preserved than any hitherto known, and they are furnished with anchoring spicules, a structural feature not previously recognized in this genus. In one species, *P. tetranema*, the number of the anchoring rods is limited to four, and the author thinks they consisted of a single cruciform spicule of which the rays were bent upward and lengthened, forming a stalk for the sponge. It may be, however, that the rods are simple, and that the apparent union at their distal ends is not original, but produced in the fossilization. In another species, *P. coronata*, there is a distinct collar of curved spicules surrounding the cloacal aperture. Judging by the characters of the detached spicules many other additional species were probably present in these sponge-beds.

The only other recognizable fossils found in connection with these sponges are a small Brachiopod referred to *Obolella* (*Linnarssonia*) *pretiosa*, Billings, and some slender plant (?) remains which are named *Buthotrephis pergracilis*. The exact horizon of the black shales is not precisely determined, but Sir W. Dawson regards them as probably near the base of the Levis division, or equivalent to the English Arenig.

II.—*Thoracosaurus macrorhynchus*, Bl., aus der Tuffkreide von Maastricht. By Ernest Koken. Zeitschr. deutsch. geol. Gesell., 1888 (1889), pp. 754–773, pl. xxxii.

A fine Crocodilian cranium, evidently from the Maastricht Beds, now preserved in the Leiden Museum, forms the subject of this memoir. A detailed description and comparison proves the fossil to be specifically identical with the so-called *Gavialis macrorhynchus*, made known by Gervais from the Upper Cretaceous of Mt. Aimé; and Dr. Koken further agrees with Dr. Leidy in referring this European type to the genus *Thoracosaurus*, which was originally founded upon a cranium from the Upper Cretaceous of New Jersey, U.S.A. The type-species of *Thoracosaurus* is said to possess antorbital vacuities, but these are not observed in the Maastricht fossil, and the author suggests that accidental fractures may have been mistaken for such in the New Jersey skull. Detailed comparisons are instituted, and the subject developes into an interesting treatise on the classification of the Crocodilia. Dr. Koken considers that *Thoracosaurus*, *Tomistoma*, and *Gavialis* are direct descendants of the Macrorhynchidæ, *Gavialis* being the most specialized form of this group, and having no intimate connection with the Teleosauridæ, which are regarded as a marine family that became extinct before the end of Mesozoic times. A long statement of anatomical facts leads to the conclusion that the Parasuchia are as nearly related to the Lizards as to the Crocodiles; and it is suggested that they may appropriately rank as equivalent to a group comprising all other so-called Crocodiles, an order Crocodiloidea being instituted, with the two suborders Parasuchia and Crocodilia. Agreeing with Lydekker, Dr. Koken considers that there is no satisfactory line of demarcation between the Mesosuchia and Eusuchia; but the arrangement adopted in the British Museum catalogue is characterized as unnatural and a purely stratigraphical classification. Amphicœlian and procœlian genera are now placed together in each of the three surviving families of Crocodilidæ, Alligatoridæ, and Macrorhynchidæ; the first arising with *Bernissartia*, the second with *Goniopholis*, and the third with *Pholidosaurus*, etc., this again subdividing into Tomistomatinæ and Gavialinæ. Incidentally it is pointed out that sclerotic plates are not peculiar to *Geosaurus*, as once stated, but that feeble ossifications occur also in the recent *Alligator*; and there is some evidence of *Cricosaurus* having possessed a dermal armour, thus differing in that respect from *Geosaurus*, as described. In a postscript, the author notes with satisfaction some recent observations of Mr. Hulke (Proc. Zool. Soc., 1888), which are in accordance with his own views. A. S. W.

III.—Première Note sur les Téléostéens du Bruxellien (Éocène moyen) de la Belgique. By Louis Dollo. Bull. Soc. Belge Géol., Paléont., Hydrol., vol iii. (1889), pp. 218–226.

M. DOLLO discusses the spines and other fragments of a Siluroid fish met with in the Bruxellian Beds of Belgium, already recorded under the name of *Silurus Egertoni*, Dixon. He concludes that these remains are specifically identical with the English Bracklesham fossils originally thus named, and agrees with the recent determination of the species as a member of the genus *Arius*.

IV.—"UEBER DEN HAUTSCHILD EINES ROCHEN AUS DER MARINEN MOLASSE." By Prof. A. BALTZER. Mittheil. Naturf. Ges. Bern, April, 1889.

AN unusually large dermal tubercle of a Ray from the Molasse of Mägenwyl, Canton Aargau, is described and figured by Prof. Baltzer. The specimen measures about 0·05 in length, is of oval outline, and appears to consist of four broad, conical tubercles fused together. A microscopical section proves the Selachian nature of the fossil, and it seems to be related to the dermal tubercles already described under the names of *Acanthobatis* and *Dynatobatis.* The author does not suggest a generic or specific determination; but a postscript states that Dr. Jaekel regards the specimen as referable to the genus *Trygon*, and will shortly describe this with other evidence of the same fish from the Swiss Molasse.

V.—A CRITICISM OF DR. CROLL'S THEORY OF ALTERNATE GLACIAL AND WARM PERIODS IN EACH HEMISPHERE, AND OF INTERGLACIAL CLIMATES. By H. H. HOWORTH, M.P., F.S.A. (Memoirs Manchester Lit. and Phil. Soc. ser. 4, vol iii. 1890.)

BRIEFLY stated, the conclusions to be drawn from Dr. Croll's theory, are "that there has been throughout geological time an alternate glaciation of each hemisphere, ultimately caused by changes in the eccentricity of the earth's orbit, and directly engendered by the greater amount of warm water forced into each hemisphere by the alternately greater potency of the Trade winds North and South of the Equator." The author grants two of Dr. Croll's postulates, namely, that climate is largely dependent on the distribution of ocean currents, and that these are chiefly dependent on the winds; but he maintains that there is no evidence that the south-east trade winds are stronger than the north-east, the fact that they blow across the equator being accounted for by the situation of the parallel of greatest mean heat being to the north of that great circle. Here we have the largest area of land, or the "furnace" which causes the winds to blow across the equator; and thus Mr. Howorth argues that the circulation of the trade winds does not depend on special differences between the temperature of the equator and that of the north or south poles, at different periods.

There is no evidence to show that any great changes have taken place in the relative distribution of land and water since the Glacial epoch, whereby the parallel of greatest mean heat might have been shifted southwards; nor can Mr. Howorth find evidence to show extensive glaciation in the southern hemisphere, as compared with the northern.

The weakness of the evidence of Glacial periods in older geological eras is discussed by the author, and coming to the Glacial period itself, he points out the uncertainty of the evidence. "We have not yet (he says) found a key by which we can give a rational explanation of the true succession of so-called glacial deposits in two adjoining counties, much less in two larger geological areas." He admits that mammoth's teeth and remains of other animals, contemporaries of man, have sometimes been found over and sometimes under Boulder-clay. This fact, no doubt, needs explanation, and can (he believes) be completely explained by an entirely different cause (as he proposes to show elsewhere). It certainly does not (in his opinion) support the theory of interglacial warm climates.

REVIEWS.

I.—ÜBER DIE GATTUNG *PRISCITURBEN*, KUNTH. Von G. LINDSTRÖM. Bihang till k. Svenska Vet.-Akad. Handlingar, Band 15, Afd. iv. No. 9 (1889), pp. 1–11, Taf. i., ii.

ON THE GENUS *PRISCITURBEN*, KUNTH. By Professor G. LINDSTRÖM, of Stockholm.

THE type forms of the genus *Prisciturben*, described by Kunth[1] as a Perforate Coral from the Silurian strata of Öland, have been unfortunately lost, and, owing to the death of this author, nothing but the description and figures remain by which the genus can be identified. Prof. Lindström thinks that the original specimens must have been derived from Gotland instead of Öland; for whilst nothing at all corresponding to the genus has been recognized from this island, there have been found in Gotland forms which agree in so many respects with Kunth's descriptions that there can be no doubt that they belong to the genus. The specimens in question are thin laminate expansions, with a concentrically rugose epitheca on the lower surface, and on the upper numerous small calices are irregularly grouped. The interspaces between the calices —described by Kunth as the cœnenchyma—are papillate and covered with delicate open channels radiating from various centres, and in this substance the calices are usually so immersed that their lateral walls are entirely concealed. The calices occur in all stages of growth; in the smallest, hardly 1 mm. in diameter, there is but a single septum developed on the lower side of the oblique calices; at a slightly older stage there are two additional septa, one on each side of the primary; these are followed by yet other two, similarly situated, and then a single septum appears on the upper side of the calice directly opposite the primary. In full-sized calices, which are not more than 4 mm. in diameter, there are from 30 to 36 septa, alternately large and small, and their outer margins are considerably thickened. The walls of the calices are faintly ribbed and sharply marked off from the cœnenchyma in which they are imbedded. The development of the septa in this Coral follows precisely the same course as that which Prof. Lindström has already noticed in many other Rugose Corals, as in *Goniophyllum*, *Cyathophyllum mitratum*, *Diphyphyllum*, sp., etc., but, curiously enough, this inequal development appears only to occur in species which in their earliest stages of growth are vermiform or tubular in shape, and attached by one side, whilst in species which are free and have a direct vertical

[1] Zeitschr. d. deutsch. Geol. Gesells. 1870, pp. 82—87, pl. 1, figs. 2*a*—2*b*.

growth, the septa are at first all of the same size and show a radial instead of a pinnate arrangement. Even in some specimens of *Prisciturben*, in which the calices have an upright mode of growth, the septa are fairly regularly radiate, without a pinnate or bilateral disposition.

Whilst the calices in *Prisciturben* exhibit all the characters of ordinary Rugose Corals, the substance in which they are imbedded, described by Kunth as cœnenchyma, shows in section a porous structure. This, on being submitted to Prof. H. A. Nicholson, was recognized by him as *Stromatopora typica*, v. Rosen, a characteristic Wenlock form occurring in England and Russia. It thus appears that *Prisciturben*, instead of being an abnormal Perforate Coral allied to the recent *Turbinaria*, really consists of two different organisms, a *Stromatopora* and a species of *Cyathophyllum*, which lived together, not always in harmony, as Lindström remarks, but rather in conflict, since in some specimens the *Stromatopora* grew at the expense of the Corals and nearly choked them, and in others the Corals were so numerous that there was little space left for the development of the *Stromatopora*. The interesting facts relating to these fossils are clearly shown in the figures which accompany Prof. Lindström's lucid descriptions. H.

II.—The Development of some Silurian Brachiopoda. By Charles E. Beecher and John M. Clarke. Forming vol. i. No. 1 of the Memoirs of the New York State Museum. pp. 95, 8 lithographed plates and 4 woodcuts. (Albany, 1889.)

WITH the completion of Davidson's great work on the Brachiopoda one might have been inclined to believe that very little more remained to be done with a group of shells upon which so much elaborate research had been expended, and with such splendid results. But we see in the volume before us how much of the life-history of the Brachiopoda yet remains to be written. Upon some of the living members of this group important treatises have from time to time appeared; notably that by Prof. E. S. Morse[1] on *Terebratulina*; another by Mr. W. K. Brooks[2] on *Glottidia*, and another by Dr. L. Joubin;[3] while M. Eugène Deslongchamps has treated of the development of the deltidium in the articulated Brachiopods. But as to the developmental history of fossil Brachiopods the field was quite open, and we are glad to see it occupied by such able and zealous workers as are the authors of the present volume. The results recorded by them could scarcely have been arrived at without the aid of rather exceptional circumstances; these were the following. A large collection of fossils[4]

[1] Mem. Boston Soc. Nat. Hist. vol. ii. "On the Early Stages of *Terebratulina septentrionalis*, pl. i. figs. 2, 3, 1869.

[2] Johns Hopkins University; Chesapeake Zoological Laboratory. "The Development of *Lingula* and the Systematic Position of the Brachiopoda," pl. i. and ii. 1879.

[3] Archiv. de Zool. Expérim. tom. iv. p. 161, 1886. A convenient abstract of this memoir has been given by Miss Agnes Crane in an appendix to the late Dr. Davidson's Monograph of Recent Brachiopoda; Trans. Linn. Soc. Lond., 2nd ser. Zool., vol. iv. pt. iii. p. 236, Oct. 1888.

[4] We are told that the collection when received weighed no less than seven tons!

was made in the Niagara group at Waldron, Indiana, for the New York State Museum (Albany, N.Y.); the specimens were separated from the shales by washing and passing the material through sieves of different degrees of fineness, and by this means a vast number (about fifty thousand) of partly developed shells were obtained, most of which were less than five millimetres, and many not more than one millimetre in length. After rejecting imperfect and badly preserved specimens, more than fifteen thousand immature individuals still remained for examination. Besides the embryonic Brachiopoda, immature forms of Gasteropods and Crinoids were also found, but the material was not sufficiently promising to repay investigation. The number of species and varieties of Brachiopoda obtained from the Waldron Shales was forty-two, ascribed to twenty-four genera. Twenty-six of these species furnished data for the observation of developmental changes; of the rest no young shells were obtained. The genera represented were *Crania, Lingula, Pholidops, Orthis, Streptorhynchus, Strophomena, Strophodonta, Strophonella, Leptæna, Streptis, Chonetes, Eichwaldia, Pentamerus, Anastrophia, Rhynchonella, Rhynchotreta, Atrypa, Zygospira, Cœlospira, Retzia, Nucleospira, Meristella, Whitfieldia, Spirifer.* Of these the following species appear to have yielded the best results:—*Streptorhynchus subplanum,* Conrad; *Strophomena rhomboidalis,* Wilckens; *Strophonella striata,* Hall; *Meristella rectirostra,* Hall; *Spirifer crispus,* Hisinger; *S. crispus,* var. *simplex,* Hall; *S. radiatus,* Sowerby; and *S. bicostatus,* var. *petilus,* Hall.

The illustrations (plates i.—vii.) consist of enlargements of the embryonic shells, usually to the size of the adult, accompanied by figures of the full-grown shells, or, if the latter were too minute to show details of structure satisfactorily, these also were enlarged to the requisite size. Figures of special structures, such as the hinge, are also added. Plate viii. represents a series of specimens ranging from the very young to the adult shell; four species are figured, viz. *Orthis elegantula* (27 examples), *Streptorhynchus subplanum* (13 ex.), *Rhynchotreta cuneata* (20 ex.), *Retzia evax* (27 ex.). These show the character and completeness of the material serving as the basis of the work. The descriptions of the species are thus arranged: first, the developmental characters are taken up, and secondly, the specific characters of the mature form, and then those of the "incipient" form, and finally the developmental phases of the latter are described, as to their general shape, beaks, foramen, plications, etc. A useful summary of these changes is furnished at the end of the book, under the heading, Size and Contour; Valves; Beaks; Cardinal Area; Internal Apparatus; Surface Ornaments; Varieties and Abnormalities; Senility. Of these the Cardinal Area afforded by far the most important phylogenetic results, and accordingly the authors have devoted several pages to a discussion of the various phases it presents in different species. After describing the development of the ventral cardinal area, the authors observe that their results, "though derived from the species of a single fauna, must not be given too limited an application, for they involve nearly every important family of Palæozoic articulate Brachiopods, and we may tentatively assume that, as a rule, the essential features of variation observed in any member of a genus will hold good of the other members. In regard to the development of the characters of the pedicle-passage, *i.e.* the deltidial plates and the foramen, there is good reason to regard the process as substantially identical in all the genera represented, making the necessary allowance for the peculiar variation seen in the Strophomenidæ, which may not, however, prove it an exception to the general statement."

After criticizing the observations of M. Eugène Deslongchamps in his "Note sur le développement du deltidium chez les brachiopodes articulés" (Bull. Soc. Géol. France, 2e sér. tom. xix. pp. 409—413, pl. ix. 1862), the authors sum up the results of their studies of the cardinal area in these words:—"It is not improbable that from an early form related to the genus *Orthis*, phylogenetic development tended in two main channels. One leading through *Strophomena*, *Scenidium*, *Orthisina*, *Leptæna*, *Chonetes*, *Productus*, and *Strophalosia*, and the other in the direction of *Rhynchonella*, *Spirifer*, *Atrypa*, *Retzia*, and *Terebratula*."

We congratulate Messrs. Beecher and Clarke upon the production of such a valuable instalment towards the complete developmental history of the Brachiopoda. A. H. F.

III.—The Vertebrate Animals of Leicestershire and Rutland. By Montagu Browne, F.Z.S. (Midland Educational Company, 1889.)

The title of this work would scarcely lead the Palæontologist to expect any items relating to his province; and the ordinary naturalist will doubtless be surprised to find elephants, rhinoceroses, bisons, reindeer, and crocodiles indiscriminately mingled with the small "game" as elements of the Vertebrate Fauna of the counties under consideration. However, notwithstanding the misfortune (as we regard it) of confusing fragments of numerous successive faunas, as if they all belonged to one period, Mr. Browne's volume is a most welcome and important addition to the literature of the subject of which it treats. The book carries out a plan we would be glad to see followed by others specially conversant with the details of local faunas, living and extinct; and its accuracy as a work of reference is insured by the care with which the author has submitted all points outside his own immediate province to the judgment of several specialists. A systematic zoological arrangement is adopted throughout, commencing with the genus *Homo* and ending with *Petromyzon*; and the latest results in taxonomy and nomenclature are almost uniformly incorporated. The records of the bones and teeth of Mammalia met with in Pleistocene and other superficial deposits are chiefly based upon the collection in the Leicester Museum, of which the work gives a tolerably complete catalogue. In addition to evidence of man dating as far back as Neolithic times, there are remains of *Elephas primigenius*, *E. antiquus*, *Rhinoceros* (?) *leptorhinus*, *Equus caballus*, *Bison priscus*, *Bos* *primigenius*, *Bos longifrons*, *Cervus elaphus*, *Capreolus capræa*, *Rangifer tarandus*, *Sus scrofa*, and the so-called *Sus palustris*. A word of warning is also added concerning Cetacean bones, which have often been introduced by man as ornamental gate-posts, and have sometimes been regarded as fossils—even ascribed in error to the mammoth. Ornithology, as may be expected, occupies the greater part of the volume, and comprises nothing of palæontological significance; but the final sections on Reptilia, Amphibia, and Pisces are concerned more with extinct than with living forms. The most important reptile-bearing stratum is the Lower Lias of Barrow-on-Soar, which has yielded *Ichthyosaurus communis*, *I. Conybearei*, *I. intermedius*, *I. tenuirostris*, *I. latifrons*, and *Plesiosaurus macrocephalus*, besides more doubtful species of the same genera. The fine example of *Ichthyosaurus* showing the pectoral fin will especially be remembered (Geological Magazine, 1889, p. 388). The Barrow quarries, moreover, yield fishes, among which are recorded *Mesodon liassicus*, *Pholidophorus Hastingsiæ*, *P. Stricklandi*, *Heterolepidotus serrulatus*, *Ptycholepis minor*, *Dapedius dorsalis*, *D. monilifer*, *D. orbis*, *D. striolatus*, *Cosmolepis Egertoni*, *Chondrosteus*, *Acrodus*, and *Hybodus*. *Belonorhynchus acutus* is also ascribed to the same locality, but the original specimen does not exhibit the ordinary physical characters of a Barrow fossil. To the Rhætic beds of Leicestershire are assigned *Ceratodus latissimus*, *Pholidophorus nitidus*, *Sargodon* (?) *tomicus*, *Gyrolepis Albertii*, *Saurichthys acuminatus*, *Acrodus minimus*, *Hybodus cloacinus*, *Hybodus minor*, and *Nemacanthus monilifer*. *Acrodus keuperinus* is represented by a spine and teeth from the Upper Keuper; *Strophodus magnus*, *Asteracanthus ornatissimus*, and *Hybodus crassus* occur in the Lower Oolites of Rutland; and there are several typical Coal-measure scales and teeth from the Ashby-de-la-Zouch Coal-field. Mr. Montagu Browne is still pursuing with success the palæontological aspect of the subject, as shown by the Addenda and more recent publications; and it may be hoped that in the next edition of the present work a considerable advance in our knowledge of the Vertebrate fossils of Leicestershire and Rutland will constitute one of its most striking features.

IV.—"Kopfstacheln von *Hybodus* und *Acrodus*, sog. *Ceratodus heteromorphus*, Ag." By Dr. Eberhard Fraas. Württ. Jahreshefte, 1889, pp. 233–240, pl. v. figs. 9–13.

The heads of *Hybodus* and *Acrodus* discovered in the English Lias usually exhibit two laterally-placed pairs of hook-shaped spines, fixed upon broad, triradiate bases. These prove that the remarkable Triassic and Rhætic fossils commonly described as *Ceratodus heteromorphus* are not Dipnoan teeth, but the cephalic spines of Hybodont sharks. Dr. Fraas makes known the various forms of these spines met with in Würtemberg, giving some figures, and proposing a definite nomenclature. Some are theoretically assigned to various species of *Hybodus* and collectively named *Hybodonchus*; while others are similarly assumed to belong to *Acrodus*, and thus termed *Acrodonchus*. It may be convenient for stratigraphical purposes to have provisional names for such fossils; but, as they possess no biological significance, we venture to think they are an unfortunate burden to scientific nomenclature. Moreover, in the present instance, the names proposed result from an imperfect acquaintance with previous researches. The term *Sphenonchus* was originally applied by Agassiz, not to the later Jurassic spines that prove to belong to *Asteracanthus*, but to the spines of *Hybodus* and *Acrodus* from the Lower Lias of Lyme Regis—a formation in which *Asteracanthus* has never been discovered. Again, the specimens in the British Museum show that there is no constant difference between the cephalic spines of *Hybodus* and *Acrodus*; and the true nature of these fossils is far from being a recent discovery, as reference to Mr. Charlesworth's paper of 1839, and Mr. Day's note of 1865, will show. If a provisional generic name of any kind be adopted, that of *Sphenonchus* thus has priority, while *Hybodonchus* and *Acrodonchus* are mere synonyms.

A. S. W.

V.—An Elementary Text-Book of Geology: intended as an Introduction to the Study of the Rocks and their Contents. By W. Jerome Harrison, F.G.S. (London, Blackie & Co., 1889.) Small 8vo. pp. 200. Price 2*s*. 6*d*.

THIS little work may be recommended as giving a concise account of the leading geological facts, under the divisions of Descriptive Geology, Palæontology, and Historical or Stratigraphical Geology. It will be useful as an elementary class-book for students, and as an introduction to the larger manuals.

A new Russian Review.

VI.—"Revue des Sciences Naturelles." Société des Naturalistes, Université, St. Petersburg. (Annual subscription, 3 roubles 50 kopeks.)

ALTHOUGH Nīkītīn's admirable "Bibliothèque géologique de la Russie" enables geologists to obtain access to Russian literature more readily than can workers in other departments of natural science, nevertheless the publication of a monthly, in addition to an annual list, cannot fail to be welcome. Hence geologists will be interested in the success of the latest addition to Russian periodical literature—the Vyestnīk Estestvoznaniya, recently commenced by the St. Petersburg Society of Naturalists. This review will consist of original articles on various branches of natural science, with short French abstracts, and a bibliography, also in French, of Russian scientific literature; the first number, which has just been issued, including three geological articles, viz. a paper by Levinson-Lessing on "Some Chemical Types of Eruptive Rocks," a report by P. N. Venyukov on the Devonian beds of Mughodzhares, and a criticism by B. Polyenov on Michel Levy's "Structure et classification des roches eruptive."

The new journal is edited by the veteran physiologist F. V.

Ovsyannīkov, but it is evident from the list of promised contributors that geology will not be neglected. This list includes, in addition to those who have written in the first number, such geologists as Inostrantzev, Karpīnskiī, Amalītzkiī, Andrusov, Dokuchaev, Vernadskiī, and Nīkolskiī, while the mineralogists are represented by Eremyeev, Zemyatchenskiī, and Tīkhomīrov. J. W. G.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Annual General Meeting, February 21, 1890.—Dr. W. T. Blanford, F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1889. In the former the Council had again to congratulate the Fellows upon the continued and apparently increasing prosperity of the Society, the affairs of which were in a very satisfactory condition. The number of Fellows elected during the year was 66, of whom 46 qualified before the end of the year, together with 15 previously elected Fellows, and these, with one Fellow readmitted, made a total accession of 62 Fellows during 1889. Deducting from this, however, 38 for losses by death, resignation, and removal, and for new Fellows compounding, the actual increase in the number of Contributing Fellows amounts to 24. The Balance-sheet for the year 1889 showed receipts to the amount of £2775 14*s.* 3*d.*, and a total expenditure of £2775 2*s.* 7*d.*, including a sum of £198 5*s.* 6*d.* expended in the purchase of stock. The balance in favour of the Society at 31st December was £249 4*s.* 1*d.* The Council's Report also referred to the Revision of the Bye-Laws completed in the spring of 1889, and in conclusion announced the awards of the various Medals and of the proceeds of the Donation Funds in the gift of the Society. The Report of the Library and Museum Committee enumerated the additions made during the past year to the Society's Library and Collections, and referred briefly to the work done in the Museum, especially with regard to the glazing of the drawers in the Cabinets.

In handing the Wollaston Medal to Prof. J. W. Judd, F.R.S., for transmission to Prof. W. Crawford Williamson, F.R.S., the President addressed him as follows :—

Professor Judd,—The Council have awarded the Wollaston Medal for the present year to Prof. W. C. Williamson, in recognition of his researches in Palæontonlogy, and especially of the series of important papers in which he has described the structure of the plants that have contributed to the formation of Coal. His investigations have added greatly to our knowledge of the Carboniferous flora, and have enabled us to form a much clearer idea of the plant-life in those far distant days of the Palæozoic era than was previously possible. Although Professor Williamson's attention has now for many years been especially devoted to the examination of fossil plants, he had, before his researches on ancient botany commenced, added many valuable details to our knowledge of the fossiliferous rocks of Yorkshire and Lancashire, and he had contributed greatly to the natural history of recent and fossil Foraminifera, whilst in a paper published more than 40 years ago, on some of the microscopical objects found in the mud of the Levant and other deposits, with remarks on the mode of formation of calcareous and infusorial siliceous rocks, he anticipated many recent discoveries, both as to the part played by minute calcareous and siliceous organisms in rock-formation, and also as to the chemical and physical changes to which such organisms are subject during the conversion of soft deposits into hard stone.

In asking you to transmit this Medal to Professor Williamson, may I further beg that you will convey to him an expression of our wishes that he may continue his important studies for many years to come, and of our regret that his engagements have unadvoidably prevented our having the pleasure of his presence on this occasion.

Prof. Judd, in reply, read the following communication received by him from Prof. Williamson:—"I need scarcely say that I feel grateful for the honour done me in awarding me the Wollaston Medal; and I trust you will not deem me presumptuous when I express a hope that it has been won by conscientious work. Though the rich deposits of fossil plants discovered in the neighbourhood of Scarborough—my native town—drew my attention to palæobotany at an early age, it was only in 1851 that I commenced the study of their internal organization. I was led to this by a specimen for which I was indebted to our distinguished colleague Professor Prestwich, and which enabled me to interpret the anomalous objects known as *Sternbergia*. The success attending this exploration whetted the appetite; and from that time until now the organization of the Carboniferous plants has received my continuous attention. The difficulties impeding my work, which have been considerable, have chiefly arisen from one cause. Most of the Carboniferous plants belong to the Cryptogamic division of the Vegetable Kingdom, the only exceptions being some ancestral forms of the modern Cycads and Conifers. At the present day these Cryptogams are mainly low herbaceous plants. But forests and forest-trees were wanted in that primæval age, which want seems to have been inadequately supplied by the Gymnosperms just referred to. The want was met by uplifting the now lowly Cryptogams into Forest giants, and since the stems of these required some organization additional to that which living Cryptogams possess, to enable them to sustain their superstructures, they were strengthened for their work by the same exogenous growth as effects that end among modern forest trees. But that any Cryptogams should attain so high an organization was deemed by most botanists so improbable that their almost universal voice rejected my views upon the subject. But the truth has prevailed, and, happily for myself, I have been spared long enough to witness this end of my labours."

In conclusion, Prof. Williamson expressed his great indebtedness to Messrs. Cash, Aitkin, Butterworth, Nield, Earnshaw, Whitaker, Spencer, Binns, Wild, and Lomax, who have collected the valuable materials employed by him in his researches.

In presenting the Murchison Medal to Prof. E. Hull, F.R.S., the President addressed him as follows:—

Professor Hull,—In handing to you, who were one of Sir R. Murchison's colleagues on the Geological Survey of Great Britain and Ireland, the Medal founded by him, I shall not attempt to enumerate the many additions that you have made to our knowledge of the geology of the British Islands and to geological literature. Your contributions to the memoirs published by the Survey on various parts of England, and especially on parts of Gloucestershire, Oxfordshire, Cumberland, Cheshire, and Lancashire, are too well known to need recapitulation; and you have done good service to the cause of science by your treatment of one of the principal geological and economical problems presented to the Survey in your 'Coal-fields of Great Britain,' a work that has deservedly passed through several editions. You have aided greatly in the important series of investigations into the underground distribution of the productive Coal-measures when concealed by later unconformable deposits, and you have applied your extensive field-experience of British rocks to solve the difficult question of land-distribution in past epochs, and to the elucidation of the physical geography of the British Islands. For several years past, whilst holding your present post at the head of the Irish Survey, you have contributed in very many different parts of the country, and by the investigation of many distinct rock-formations, to our knowledge of Irish geology, and by your visit to Palestine you have been able to throw much light on the geological structure of the Holy Land.

Prof. Hull, in reply, said:—I appreciate very highly the honour which you and the Council have conferred in awarding to me the Murchison Medal. The gratification I feel is enhanced by the circumstance that this distinction is associated with the name and memory of the founder, who was to me a wise and considerate chief as well as a personal friend.

You have been pleased to refer to my official work on the Geological Survey of the United Kingdom, as well as to that of a more personal nature. It has been my lot to serve under four successive chiefs, namely, De la Beche, Murchison, Ramsay, and Dr. Geikie, whose names will ever be associated with the early history and progress of geological science; and I may truly say that from each and all I received that encouragement and support which is essential to the hearty fulfilment of the duties of a public servant; and I am glad to have this opportunity of saying that in bringing the Geological Survey of Ireland to its completion I have been associated with colleagues in this work who have combined an earnest desire to fulfil their duties to the public service with no small amount of enthusiasm in carrying on scientific investigation. In view of my pending retirement from this department of the public service, I am somewhat consoled by the hope that, in consequence, I may be enabled, at no distant day, to take a more active part in the work of this great Society than has hitherto been possible. In conclusion, I have only to express my thanks to you, Mr. President, for the kind words in which you have communicated to me the award of the Council; these will be an incentive to further effort in the cause of geological investigation.

The President then presented the Lyell Medal to Prof. T. Rupert Jones, F.R.S., and addressed him as follows:—

Professor Rupert Jones,—There is unusual pleasure in presenting one of the chief awards in the gift of the Council to a geologist who has been so long and so honourably associated with the Geological Society as yourself, and the appropriateness of the award is not decreased by the circumstance that your official connexion with the Society commenced when the great geologist who founded this medal was President. Since that time, now forty years ago, you have written much on various fossil organisms, but especially on Entomostraca and Foraminifera, and in many cases, and especially amongst the bivalve crustaceans of the older rocks, it is largely to your researches that we are indebted for our present knowledge of the forms. You have also devoted much time and attention to the geology of South Africa, and to bringing together the scattered information that we possess concerning the geology of that interesting region.

In placing the Lyell Medal in your hands I can only add that I think the Council have carried out the intentions of Sir Charles Lyell, and that they are justified in believing that, in his words, "the Medallist has deserved well of the Science."

Prof. T. Rupert Jones, in reply, said:—Acknowledging, with respectful thanks, the unexpected honour with which the Council, on the part of the Society, has favoured me, I beg to state that, in following the study of those branches of geological science to which opportunity and other circumstances have led me to give my best attention, I cannot claim to have been so successful, or so useful, or deserving of such honourable recognition as the Council, in their kindness towards an old worker, seem to have considered me to be.

Thanks to a natural disposition to study both living and fossil organisms, and to look with confidence for signs of the great Divine laws governing the earth and all its belongings, my humble part has been, as far as possible, that of a true "Minister et Interpres Naturæ."

No great discovery, however, nor signal success in elucidating the problems offered for our study, in the organic and the inorganic world, has been attained by me. Persistent and, may be, an industrious search among geological facts for their causes and history, and among fossils, especially microzoa, for evidence of their exact relationships, to the end that our knowledge of these things should be more perfect and more useful, has occupied much of my intellectual life.

How far the Foraminifera, Ostracoda, and Phyllopoda have been already, or will in the future be useful palæontological guides to the geologist cannot be noticed here.

In all that I have done my work has been my pleasure, and I can claim no reward for it; and in all that has been good I have to acknowledge warmly the co-operative help given by W. K. Parker, J. W. Kirkby, H. B. and G. S. Brady, Henry Woodward, and C. D. Sherborn; and in just now completing the Supplemental Monograph of the Cretaceous Entomostraca I have had the kind aid of G. J. Hinde.

This Medal, Sir, bequeathed by my old and revered friend Sir Charles Lyell, and the other Awards given so graciously this day by the Council and yourself, on behalf of the Geological Society, bear striking and pleasant testimony to the fact that the good deeds of great and good men live after them.

The President next presented the Balance of the Wollaston Fund to Mr. W. A. E. Ussher, F.G.S., and said :—

Mr. Ussher,—In connexion with the Geological Survey of the counties of Somerset, Devon, and Cornwall, it has been your province to examine many of the rocks exposed, and in addition to your official work you have contributed several useful accounts of the Palæozoic, Triassic, and Pleistocene deposits to the Journal of this Society and to other geological publications. In recognition of the good work done by you the Council have authorized me to present you with the balance of the Wollaston Donation Fund.

Mr. Ussher, in reply, said:—I thank the Council for the recognition of work this Award implies, and you, Sir, for your allusions to it. Whatever results I may have obtained in the discharge of my ordinary duties on the Geological Survey are not deserving of reward. The construction of maps may be faithfully performed without obtaining results of moment in the furtherance of geological knowledge; official requirements are so engrossing and imperative as to oblige those who, like myself, desire to acquire as competent an acquaintance as possible with the strata on which they are employed, to supplement, by private work, the information acquired in public duty. The results obtained by private investigation, whensoever they contribute to the advancement of our common science, are in themselves rewards.

The result of my twenty years' experience in geological mapping is this:—the acquirement of patience and the entire subordination of theoretical considerations, which should be the outcome of a careful study, collation and comparison of details, and not the working hypothesis to weld them into system during or before the progress of the work.

This principle I have had to keep in view in Pleistocene work, in dealing with a variable and disturbed series of Triassic rocks, and to a still greater extent in dealing with fossiliferous rocks such as the Lias, Oolites, Carboniferous, and Devonian. I have learned the extreme importance of Palæontology in investigating disturbed Palæozoic areas, where it appears to me that the evidences of fossils and of stratigraphy should be taken together, and without subordinating the one as a mere adjunct to the other.

In presenting the Balance of the Murchison Geological Fund to Mr. E. Wethered, F.G.S., the President addressed him as follows:—

Mr. Wethered,—The remainder of the Murchison Donation Fund has been awarded to you by the Council of this Society on account of the researches you have undertaken into the microscopic structure of sedimentary rocks, and to aid you in prosecuting further inquiries. The results of your examination of the insoluble residues obtained from the Carboniferous Limestone, and of the remarkable minute tubular forms (apparently organic) from various limestones, that you have ascribed to *Girvanella*, are of great interest, and have furnished an important contribution to our knowledge of the manner in which Palæozoic and Mesozoic limestones have been formed.

Mr. Wethered, in reply, said:—I desire to express to the Council my thanks for the honour done me in making me the recipient of the Murchison Fund for the year. This kind consideration will greatly encourage me in pursuing that branch of geological research which I have marked out as one of the objects of my life. To have done work which merits the acknowledgment of this Society—the first in the world—is one of the greatest satisfactions a geologist can enjoy.

You have referred to my work on the microscopical examination of limestones, and I should like to say that in this there is a most important field open for investigation. If those who have the opportunity of examining the oldest limestones would do so through the microscope, with due regard in preparing the slides to the optical properties of the rock, my belief is that our knowledge of the life which existed at that early period of the earth's history would be considerably advanced.

I again return my thanks for the honour done me.

The President then presented the Balance of the Lyell Geological Fund to Mr. C. Davies Sherborn, F.G.S., and said :—

Mr. Davies Sherborn,—There is no branch of scientific work at the present day that confers a greater benefit on geologists in general than the recording of geological and palæontological literature. Owing to various causes, the mass of published matter increases yearly; and as it is impossible for any one to read all that appears, a heavy debt is due to those who undertake the arrangement of a key to the various publications. In Palæontology this is even of greater importance than in Geology. In your recently published 'Bibliography of the Foraminifera,' and in the Catalogue of 'British Fossil Vertebrata,' published in conjunction with Mr. Smith Woodward, you have contributed to that important object the establishment of a general palæontological list with full references; whilst in the assistance given to the 'Geological Record' you have done good service to the science for the advancement of which this Society exists. As a mark of the value attached by the Council to the completion of a general index to palæontological writings, and as an assistance in the compilation of any portion of the work that you may undertake, I have much pleasure in presenting to you the Balance of the Lyell Donation Fund.

Mr. Sherborn, in reply, said:—I must ask you, Sir, to express my thanks to the Council for the distinction they have shown me in awarding me the Proceeds of the Lyell Fund. I feel great diffidence in accepting such award, my work having extended over but few years. I have endeavoured to make that work as perfect as possible, and hope to devote my future time to bibliographic research. I wish to thank Prof. Rupert Jones and Mr. Topley for first assistance in my work, and I assure you, Sir, I shall always labour to make my work more perfect.

In presenting to Mr. W. Jerome Harrison, F.G.S., a grant from the Proceeds of the Barlow-Jameson Fund, the President addressed him as follows:—

Mr. Harrison,—In awarding to you a grant from the Barlow-Jameson Fund, the Council recognize the value of your endeavours to spread a knowledge of Geology by the compilation and publication of hand-books to the Geology of the Counties in England and Wales. They also appreciate your geological researches in the Midland Counties, and trust that the award now made may be of use to you in the prosecution of future efforts to extend geological knowledge.

Mr. Harrison, in reply, said:—In thanking the Council for the honour they have conferred upon me, I can only say that their award was as unexpected as it was welcome. The daily tasks of a necessarily busy life have left me but little time for original research, and I have done—not what I *would*, but what I *could*. This recognition of my labours, and the kind words with which you have accompanied it, will spur me on to increased endeavours in those studies which the Geological Society was established to promote.

The President then read his Anniversary Address, in which, after giving obituary notices of several Fellows, Foreign Members, and Foreign Correspondents deceased since the last Annual Meeting, including the Venerable Archdeacon Philpot (who was the senior Fellow of the Society, having joined it in 1821), Dr. H. von Dechen (the oldest Foreign Member, elected in 1827), Mr. Robert Damon, Mr. J. F. LaTrobe Bateman, Mr. H. W. Bristow, Dr. John Percy, the Rev. J. E. Tenison Woods, Mr. Thomas Hawkins, Prof. F. A. von Quenstedt, Prof. Bellardi, Dr. Leo Lesquereux, and Dr. M. Neumayr, he referred briefly to the condition of the Society during the past twelve months and to a few works on palæontological subjects published in the same period. He also mentioned the finding of Coal *in situ* in a boring at Shakspere's Cliff, and then proceeded with the main subject of his Address, namely, the question of the Permanence of Continents and Ocean-basins. After reviewing the evidence derived from the rocks of oceanic islands, and the absence of deep-sea deposits in continental strata of various ages, he proceeded to the points connected with the geographical distribution of animals and plants, and gave reasons for believing that Sclater's zoological regions, founded on Passerine birds, were inapplicable to other groups of animals or plants, and that any evidence of continental permanence based on such regions was worthless. He also showed that both elevations and depressions exceeding 1000 fathoms had taken place in Tertiary times, and gave an account of the biological and geological facts in support of a former union between several lands now isolated, and especially between Africa and India *via* Madagascar, and between Africa and South America. From these and other considerations it was concluded that the theory of the permanence of ocean-basins, though probable, was not proved, and was certainly untenable to the extent to which it was accepted by some authors.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year :—*President*: A. Geikie, LL.D., F.R.S. *Vice-Presidents*: Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; W. H. Hudleston, Esq., M.A., F.R.S.; J. W. Hulke, Esq., F.R.S. *Secretaries*: H. Hicks, M.D., F.R.S.; J. E. Marr, Esq., M.A. *Foreign Secretary*: Sir Warington W. Smyth, M.A., F.R.S. *Treasurer*: Prof. T. Wiltshire, M.A., F.L.S. *Council*: Prof. J. F. Blake, M.A.; W. T. Blanford, LL.D., F.R.S.; Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.; James Carter, Esq.; John Evans, D.C.L., LL.D., F.R.S.; L. Fletcher, Esq., M.A., F.R.S.; A. Geikie, LL.D., F.R.S.; Prof. A. H. Green, M.A., F.R.S.; A. Harker, Esq., M.A.; H. Hicks, M.D., F.R.S.; Rev. Edwin Hill M.A.; W. H. Hudleston, Esq., M.A., F.R.S.; J. W. Hulke, Esq., F.R.S.; Major-Gen. C. A. McMahon; J. E. Marr, Esq., M.A.; H. W. Monckton, Esq.; E. T. Newton, Esq.; F. W. Rudler, Esq.; Sir Warington W. Smyth, M.A., F.R.S.; W. Topley, Esq., F.R.S.; Rev. G. F. Whidborne, M.A.; Prof. T. Wiltshire, M.A., F.L.S.; H. Woodward, LL.D., F.R.S.

II.—February 26, 1890.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communication was read:—

"On the Relation of the Westleton Beds or 'Pebbly Sands' of Suffolk to those of Norfolk, and on their Extension inland, with some Observations on the Period of the Final Elevation and Denudation of the Weald and of the Thames Valley."—Part III. On a Southern Drift in the Valley of the Thames, with Observations on the Final Elevation and Initial Subaerial Denudation of the Weald, and on the Genesis of the Thames." By Prof. Joseph Prestwich, D.C.L., F.R.S., etc.

In this third part of his paper the author gave a description of the character of the Southern Drift, showing how it differs from the Westleton Beds in the nature of its included pebbles, which consist of flints from the Chalk with a large proportion of *chert* and *ragstone* from the Lower Greensand, while there is a total absence of the Triassic pebbles and Jurassic débris characterizing the Northern Drift. He traced the drift through Kent, Surrey, Berkshire, and Hampshire, and described its mode of occurrence.

Another preglacial gravel was then discussed under the title of the Brentwood group, and its age was admitted to be doubtful.

The author then entered into an inquiry as to the early physiographical conditions of the Wealden area, and gave reasons for supposing that a hill-range of some importance was formed in the Pliocene period after the deposition of the Diestian beds. From the denudation of this ridge, he supposes that the material was furnished for the formation of the Southern Drift, which may have been deposited partly as detrital fans at the northern base of the range.

The relation of the Southern Drift to the Westleton Shingle and other preglacial gravels was considered, and the Westleton Beds were referred to a period subsequent to that of the formation of the Southern Drift.

The influence of the meeting of the earlier Wealden axis with that of the folding which produced the escarpments of central England was discussed, and it was suggested that the result would be the genesis of the Thames-valley and river.

The following summary gives the results of the author's inquiry as developed in the other parts of the paper. He holds:—

1. That the Westleton shingle ranges from Suffolk to Oxfordshire and Berkshire, rising gradually from sea-level to 600 feet.

2. That the lower Tertiary strata were coextensive with this shingle.

3. That the upraising of the Westleton sea-floor, with its shingle, preceded the advance of the glacial deposits, and that the latter became discordant to the former when traced westward, occupying valleys formed after the rise of the Westleton Beds.

4. That the Tertiary strata and Westleton Beds on the north border of the Chalk-basin were continuous until the insetting of the Glacial period, when they were broken through by denuding agencies.

5. That none of the present valleys on the north of the Thames Tertiary-basin date back beyond the Preglacial period.

6. That the same date may be assigned to the Chalk-, and probably to the Oolite-escarpments.

7. That in the Thames-basin, besides the Northern Drift, there is a Southern Drift derived from the Lower Greensand of the Wealden area, and from the Chalk and Tertiary strata formerly extending partly over it.

8. That during the Diestian period the Weald was probably partly or wholly submerged, and that between this and the insetting of the Glacial period, the Wealden area and the Boulonnais underwent upheaval, resulting in the formation of an anticlinal range from 2000 to 3000 feet high.

9. That from the slopes of this range the materials of the Southern Drift were derived, and spread over what is now the south side of the Thames basin.

10. That this denudation commenced at the time of the Red Crag, and went on uninterruptedly through successive geological stages.

11. That consequently, though the Southern Drift preceded the Westleton shingle, the two must at one time have proceeded synchronously.

12. That the valley-system of the Wealden area dates from Pliocene times,—the initial direction of the transverse valleys from Preglacial times,—and of the longitudinal valleys from Glacial times.

13. That the Thames basin results from the elevation of the Weald and the flexures of the Chalk and Oolites of the Midland counties, and dates from a period subsequent to the Westleton Beds.

14. That the genesis of the Lower Thames similarly dates from early Pleistocene times, whilst its connection with its upper tributaries and the Isis, which possibly flowed previously north-eastward, took place at a rather later period.

III.—March 12, 1890.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read :—

1. "On a Deep Channel of Drift in the Valley of the Cam, Essex." By W. Whitaker, Esq., B.A., F.R.S., F.G.S.

In Scotland and in Northern England long and deep channels filled with Drift have been noticed, but not in Southern England.

For some years one deep well-section has been known which showed a most unexpected thickness of Glacial Drift in the higher part of the valley of the Cam, where that Drift occurs mostly on the higher grounds and is of no very great thickness. Lately, further evidence has come to hand, showing that the occurrence in question is not confined to one spot, but extends for some miles. The beds found are for the most part loamy or clayey.

At the head of the valley various wells at Quendon and Rickling show irregularities in the thickness of the Drift, the Chalk coming to or near the surface in some places, whilst it is nearly 100 feet below it sometimes.

Further north, at Newport, we have the greatest thickness of Drift hitherto recorded in the South of England, and then without reaching the base. At one spot a well reached Chalk at 75 feet; whilst about 150 feet off that rock crops out, showing a slope of the Chalk-surface of 1 in 2. In the most interesting of all the wells, after boring to the depth of 340 feet, the work was abandoned without reaching the Chalk, the Drift in this case reaching to a depth of about 140 feet below the level of the sea, though the place is far inland. The Chalk crops out about 1000 feet eastward, and at but little lower level, so that there is a fall of about 1 in 3 over a long distance.

At and near Wenden the abrupt way in which Drift comes on against Chalk has been seen in open sections. Two wells have shown a thickness of 210 and 296 feet of Drift respectively; and as the Chalk comes to the surface. at a level certainly not lower, only 140 yards from the latter, the Chalk-surface must have a slope of I in less than $1\frac{1}{2}$, and this surface must rise again on the other side, as the Chalk again crops out. The Drift here reaches to a depth of 60 or 70 feet below the sea-level.

At Littlebury, in the centre of the village, a boring 218 feet deep has not pierced through the Drift, which reaches to 60 feet below the sea-level. As in a well only 60 yards west and slightly higher, the Chalk was touched at 6 feet, there must here be a fall of the Chalk-surface of about 1·2 in 1. Eastward too, on the other side of the valley, the Chalk rises to the surface.

The places that have been mentioned range over a distance of 6 miles. How much further the Drift-channel may go is not known, neither can we say to what steepness the slope of the underground Chalk-surface may reach; the slopes given in each case are the lowest possible.

The author thinks that the channel has been formed by erosion rather than by disturbance or dissolution of the Chalk.

2. "On the Monian and Basal Cambrian Rocks of Shropshire." By Prof. J. F. Blake, M.A., F.G.S.

In a previous paper the author had suggested that the Longmynd rocks were referable to the Upper Monian. He now finds that they are divisible into two groups, of which the lower only can be thus referred.

This lower group is divisible into five parts:—1. Dark Shales; 2. Banded Series; 3. Purple Slates; 4. Hard Greywackés; 5. Pale Slates and Grits. These are shown to have a real dip to the west, and not to be thrown into any folds. It is in these only that fossils have been found. The lowest dark shales are not basal rocks, nor derived from the eastern volcanic series.

The junction of the upper group, which represents the true Cambrian, is unconformable, as shown by detailed stratigraphy. It consists of three members, the middle one being slates which die out northwards. There is neither synclinal nor anticlinal fold, but a regular sequence and dip; and pale slates follow on the west. The base is brought into connexion with each division of the lower series except No. 2. The conglomerates contain:—1. Quartz; 2. Rhyolites; 3. Gneissic rocks; 4. Slates like those of the underlying group. The supposed Archæan masses on the western border are non-existent, being intrusive and transgressive igneous rocks.

The volcanic group on the east is not bounded by the main fault, the dark shales lying to the east of that fault. Evidence is given that the volcanic rocks have been protruded through these shales, which they have altered. The Eurite of the Wrekin is of later date, and the only possible older rocks are the Rushton Schists and the fragments of schistose rocks on Primrose Hill.

At several places patches of red grit and conglomerate are seen on the Volcanic hills; these are referred to the Cambrian, and their connexion also with earlier conglomerates forming part of the Volcanic series is suggested. The Cambrian quartzite is later than all these, but may be synchronous with the upper part of the western Grits.

The Volcanic rocks are not, therefore, Middle Monian, as formerly supposed, but represent the interval between Monian and Cambrian. If classed with either, the author inclines rather to place them with the Cambrian, in spite of the unconformity of the quartzite. He regards them as probably the equivalents of the Bangor Series, and possibly of the St. David's Volcanic Group. If this classification be adopted, then the Monian system will be entirely separated from the Pebidian, and be established on distinct and independent observations.

3. "On a Crocodilian Jaw from the Oxford Clay of Peterborough." By R. Lydekker, Esq., B.A., F.G.S., etc.

The symphysis of the mandible of a Thecodont Reptile obtained by Mr. Leeds from the Oxford Clay near Peterborough was described by the author, and reasons were given for referring it to the Crocodilia rather than to the Sauropterygia. An imperfect skull found by Mr. Leeds in the same formation at Peterborough appears to belong to the same form as the mandible, and shows that the latter cannot be referred to *Machimosaurus.*

After reviewing the whole of the evidence, the author concluded that he was dealing with a Crocodilian allied to *Metriorhynchus*, but forming the type of a new genus, to which he gave the name of *Suchodus*, adding the specific name of *durobrivensis.*

4. "On two new Species of Labyrinthodonts." By R. Lydekker, Esq., B.A., F.G.S., etc.

The right ramus of the lower jaw of a Labyrinthodont, from the Lower Carboniferous of Gilmerton, near Edinburgh, is regarded as referable to the Permian genus *Macromerum*, and it is proposed to describe it as *M. scoticum.*

Another mandible from the Karoo system of South Africa is referred to the American Permian genus *Eryops* under the name of *E. Oweni.*

CORRESPONDENCE.

THE CRYSTALLINE SCHISTS OF THE LEPONTINE ALPS.

Sir,—To the abstract of my paper on "The Crystalline Schists and their Relation to the Mesozoic Rocks in the Lepontine Alps," read before the Geological Society on January 22nd, and reprinted in the last Number of this Magazine, has been appended a long letter written by Dr. Heim in anticipatory criticism, which was read during the discussion. As the printing of that letter *in extenso* appears to me to be a feature even more novel in your Magazine than it is in the Abstracts of the Geological Society, I request space for the following remarks :—

1. I must leave to casuists more experienced than myself the task of reconciling certain parts of that letter (as to what has been said by Swiss geologists) with the paper, presented by Dr. Heim to the International Geological Congress in 1888. After comparing them, I can only put the old question, "What then does Dr. Heim mean ?"

2. The Carboniferous rocks of the Alps were only incidentally mentioned in my paper. But I know something of these also, and shall be surprised if it can be proved that any sedimentary rocks of this age have been converted into true crystalline schists, or that the "Calamite-like trunk from Guttanen" (which I have seen) occurs in a gneiss.

3. In regard to the "crystalline schistose rocks" of Mesozoic age, in which it is stated that Belemnites occur with staurolites, garnets, etc.,—rocks which are now said not to be true crystalline schists—I have only to remark that the whole aim of my paper was to show that the rocks with garnet, staurolite, etc., were true crystalline schists, that they were totally distinct from the schistose rocks with fossils, that the former were below not above the (Triassic) rauchwacké, in which some of their members actually occur as fragments, that the Belemnite-bearing rocks have only a superficial

resemblance to the schists with garnet and staurolite, and that the authigenous minerals in them are neither garnet nor staurolite, but some impure hydrons silicates. Dr. Heim's letter merely asserts the contrary to my contentions, without adducing any fresh evidence.

T. G. Bonney.

THE CULM-MEASURES AT BUDE, NORTH CORNWALL.

Sir,—I have read with much interest the paper by Major-General McMahon on the rocks at Bude. During one of two summer visits to Tintagel I made a short stay at Bude, and saw the extremely contorted strata so well described in the paper referred to. Like the author of that paper, I was desirous of seeing what amount of metamorphism had resulted from so much pressure and dislocation, but expecting to pay a longer visit I took away only two specimens. These were taken from two layers, a few inches apart, of a very sharp fold exposed in a cove a little way south of Bude Haven,—I think it was "Efford Ditch." One of the layers was darker in colour, much softer, and more laminated than the other.

If any conclusions may be drawn from so limited a stock of material (and macroscopically, at least, my specimens appeared fairly representative of many of the rocks in this and other cliffs of the district), the rocks of Bude are entitled to complain that they have been made to appear as being less appreciative of, and as making less return for, the large amount of force expended on them than is really the case.

The microscope shows the general structure and composition of my specimens to be exactly as described by Major-General McMahon; but a close study of very thin portions of slides, under high powers, shows a good deal more, especially in the harder of the two layers.

In among the unaltered original clastic material may be seen a considerable amount of rutile, perfectly distinct from any bits of that mineral which may have come from older rocks. There are large numbers of acicular crystals of it, vividly polarizing, as well as countless minute dark rods, so well shown in many slates, etc. It is also present in grains and granular aggregates, and in plates, some of them of relatively large size. The total amount of it varies much, even in slides from the same small piece, but it is always considerable, and in one slide from the harder layer of rock it is particularly abundant. This slide also shows a good many long crystals of tourmaline (quite distinct from the clastic grains of that mineral) and a good deal of secondary sericitic mica, some of it rich in rutile crystals. Indeed, parts of this slide at once remind one of some of the sericite-phyllites of the Tintagel rocks, in which the rutile occurs in just the same manner; and comparisons of the two leave little doubt that some at least of the Bude strata have made a good start towards the metamorphism which is so intense at Tintagel.

Of course it may be that my two specimens are exceptional, and that Major-General McMahon did not chance on these or similar layers.

But in any case, even though these specimens show that *all* the Bude rocks are not without distinct evidence of metamorphic action, it is still true that the effect produced is not in anything like the proportion we might expect, from the stresses endured by these beds.

I am not able to follow some of the reflections which Major-General McMahon bases on the supposed total absence of alteration at Bude.

Hallock's experiments (as quoted), and still more Hallock's conclusion from them, seem to be beside the mark. It is not generally supposed that pressure is able to liquefy rocks,—quite the reverse in fact,—and there does not seem to be any justification for saying that "consequently" no chemical or mineralogical changes are to be expected.

Again, Spring's experiments are admitted to have proved that pressure can produce chemical combinations and re-arrangements; and nothing that was done by "Professor Spring's pestle and mortar" would be lacking in the intermixture of minute particles of minerals in the fine silt of which these Bude rocks and similar strata are largely composed. There is no call here for rocks to be "crushed and ground to pieces by irresistible geological disturbances." All the crushing and grinding has been done in the gentlest and quietest way, and the resulting material has but to lie and await the pressure.

Whether pressure, with or without movement, is in itself sufficient to intensely metamorphose sedimentary rocks, is another question.

And, if it *is* sufficient, there is still much room for inquiry and speculation as to why it acts so comparatively feebly at one place and so very intensely a few miles away, when, so far as can be judged from the rocks, the feebler metamorphism has by no means corresponded to feebler stresses.

Newcastle-on-Tyne, W. Maynard Hutchings.
March 10th, 1890.

CONTORTION AND METAMORPHISM.

Sir,—General McMahon's "Notes on the Culm-measures at Bude" in the March Number of this Magazine (p. 106) form a welcome contribution to the petrology of the district, and have a particular interest as indicating the probable derivation of the strata in question from the destruction of granitic rocks. The fact that the Culm-measures are much contorted without having experienced any appreciable mineralogical changes seems, however, to have only a limited bearing on the general question of metamorphism by pressure.

Adopting the familiar treatment employed by Thomson and Tait, we may usefully resolve any system of strains into (i) a uniform voluminal compression and (ii) certain shears. The term shear is here used in its strict sense, viz. deformation apart from change of volume, and it is evident that the varying amounts of shearing from point to point within the mass express themselves completely in the contortion of the rocks affected, faulting being regarded for this purpose as a particular case of contortion. In like manner the correlated stresses resolve into (i) a uniform pressure and (ii) certain shearing stresses. The energy set free consists of two parts; (i) that due to compression, measured by the product of the uniform pressure into the relative compression, and (ii) that due to shearing, measured by the products of the shearing stresses into the amounts of the corresponding shears. The total energy thus set free, except in so far as it is lost by conduction of heat, must be absorbed in the production of mineralogical changes. Rocks are known to be very bad conductors of heat, but the amount of energy lost in this way must vary with circumstances, time being an important factor.

Again, viewing the strains and stresses in a rock-mass with reference to the external forces that produce them, it is essential to notice that the voluminal compression and uniform pressure depend upon the *sum* of the forces acting in different directions (*e.g.* vertically and horizontally) while the shears and shearing stresses depend upon the *differences* of those forces. We may, for example, picture a mass of rocks subjected to a lateral thrust and to the weight of overlying rocks. If the mass be situated at no great depth, the latter force may be very much less than the former, and considerable shearing may be produced if the material be not a very rigid one, or if the thrust be of long duration; for shearing is, within limits, proportional to the time. The pressure and the total energy set free may or may not be very great, and under a comparatively small cover of rocks much of the energy must be lost by conduction. It is thus easy to imagine conditions under which any amount of contortion may be produced without any metamorphism of the rocks so affected.

If the same lateral thrust operate upon a rock-mass at a greater depth beneath the surface, it will be more nearly balanced by the weight of the cover, and so the compression and pressure will be greater, but the shears and shearing stresses less. The total energy set free will be greater, and there will be less loss by conduction. We may thus have metamorphism produced with or without contortion.

In the case of rocks at a depth, too, the time-element must be important. The rigidity of the mass being there materially diminished —this, at least, is generally admitted—there must be a tendency to propagate pressure uniformly, as in a liquid. If this property hold good to any extent, shearing stresses cannot be set up unless the disturbing forces increase comparatively suddenly. However this may be, it appears that the contortion of rocks cannot afford an accurate measure of the forces which have produced it, and that contortion and dynamo-metamorphism, though due to the same ultimate cause, are by no means necessarily associated in the same place. One or the other phenomenon may occur alone, or both together, in accordance with complex conditions, such as the depth of the cover, the rigidity of the rocks affected, and the slowness or rapidity of development of the disturbing forces.

General McMahon apparently calls in question the experimental researches of M. Spring and others on the physical and chemical changes produced by the action of high pressures. It seems rather rather late in the day to take this position, but the subject is too wide to be discussed here. The Belgian physicist, too, is well able to defend himself: witness his reply to the American critic cited by General McMahon. ALFRED HARKER.

ST. JOHN'S COLLEGE, CAMBRIDGE.

COCCOSTEUS DECIPIENS.

SIR,—In a very important paper on the structure of *Coccosteus decipiens*, Ag., Dr. Traquair has recently remarked (Ann. & Mag. Nat. Hist. [6] vol. v. p. 125) that he suspects I have mistaken the lateral margin of the interlateral plate for a pectoral spine in my description of *Coccosteus*, and he feels justified in asserting that, if such a pectoral swimming organ does really exist in *C. Bickensis*, that species cannot be referred to *Coccosteus*, in which no such appendage is present.

In reply, I must repeat that there occurs a hollow, triangular, bony spine, filled with calc spar, quite distinct from the other plates. Apart from this spine, *C. Bickensis* agrees so well with undoubted species of *Coccosteus*, that I am inclined to regard Dr. Traquair's statement cited above as not yet beyond question; and although a similar pectoral organ has not yet been recognized in Scottish specimens, it is quite likely it may still be found. I am all the more confirmed in this opinion since, according to Dr. Traquair, the sclerotic ring appears to exist only in *one* specimen from Gamrie in the Edinburgh Museum, while it is rather common in my German specimens. The pectoral spine is much more rarely seen in my fossils than the sclerotic ring, and I am thus not astonished that it should hitherto have escaped observation in the Scottish examples of *Coccosteus*. Finally, I would add that the spine in *C. Bickensis* attained a length of 55mm. (fig. 12 of my paper on Placoderms), but the end is wanting, the impression of it being retained on the rock. It is therefore not shorter, but much longer than in the restoration of *Brachydeirus inflatus*.

I may add that my specimens are exposed in the Royal Geological Museum here at Göttingen, and may be examined by any one interested in the subject. A. VON KOENEN.

GÖTTINGEN, *March 12th*, 1890.

TIDAL ACTION.

SIR,—As tidal action has been called in of late in your pages to assist if possible in solving the riddle of the Triassic sandstones and conglomerates, it may be well to point out one line of evidence which seems to have been overlooked by the supporters of the tidal theory, *i.e.* the zoological.

Mr. Mellard Reade writes as follows in the Philosophical Magazine, vol. xxv. p. 342:—"Although it is on the littoral margins and the shallow seas opening into the oceans that the resistless force of the tides is most obvious," etc., etc.[1]

[1] See Mr. Mellard-Reade's Article in this Number, *supra*, p. 157.—ED. GEOL. MAG.

The English Channel is an excellent test case. It is shallow and opens full into the Atlantic Ocean. It lies east and west, and accordingly offers no impediment to the free play of the currents generated by the tidal wave which runs from east to west.

If unchecked tidal currents are anywhere resistless, they should be so here. Do these tidal currents disturb the gravel, or sand or even the mud on the Channel bottom? The marine fauna of the district answers this question with an emphatic negative.

It is generally admitted that very few molluscs can exist in an area of shifting sand, and the denizens of the Channel bottom are not of the number. They are, it is true, wonderfully provided with diverse defences against currents of a peculiar nature, viz. the alternating currents set up by waves; but even these must not be too violent, or the molluscs will perish by the million, as indeed they often do from this cause alone.

Geologists interested in the question of denudation and distribution by tides and waves will be familiar with Delesse's "Lithologie du Fond des Mers," and the admirable atlas accompanying that volume. If they will turn to Map 2, they will note that the area of the English Channel most frequented by shells extends from west of the Land's End to Ushant, and up the centre of the Channel to a point off Exmouth; with another large sandy area of shells west of Ushant. These are precisely the localities where we might expect the tidal currents to make a clean sweep of the Channel bottom, but nothing of the sort occurs. The presence of this Molluscan fauna in these very exposed localities is good proof that unchecked tidal currents sweeping over a fairly level sea-bottom are incapable by their own unassisted efforts of raising the sand; a glance at the map will show that they cannot even wash away the mud.

This being my special craze, and having noted observations and experiments thereon for many years, on shore and afloat, I could fortify my position at such length as would insure this letter finding a place in the editorial waste-paper basket, so I refrain.

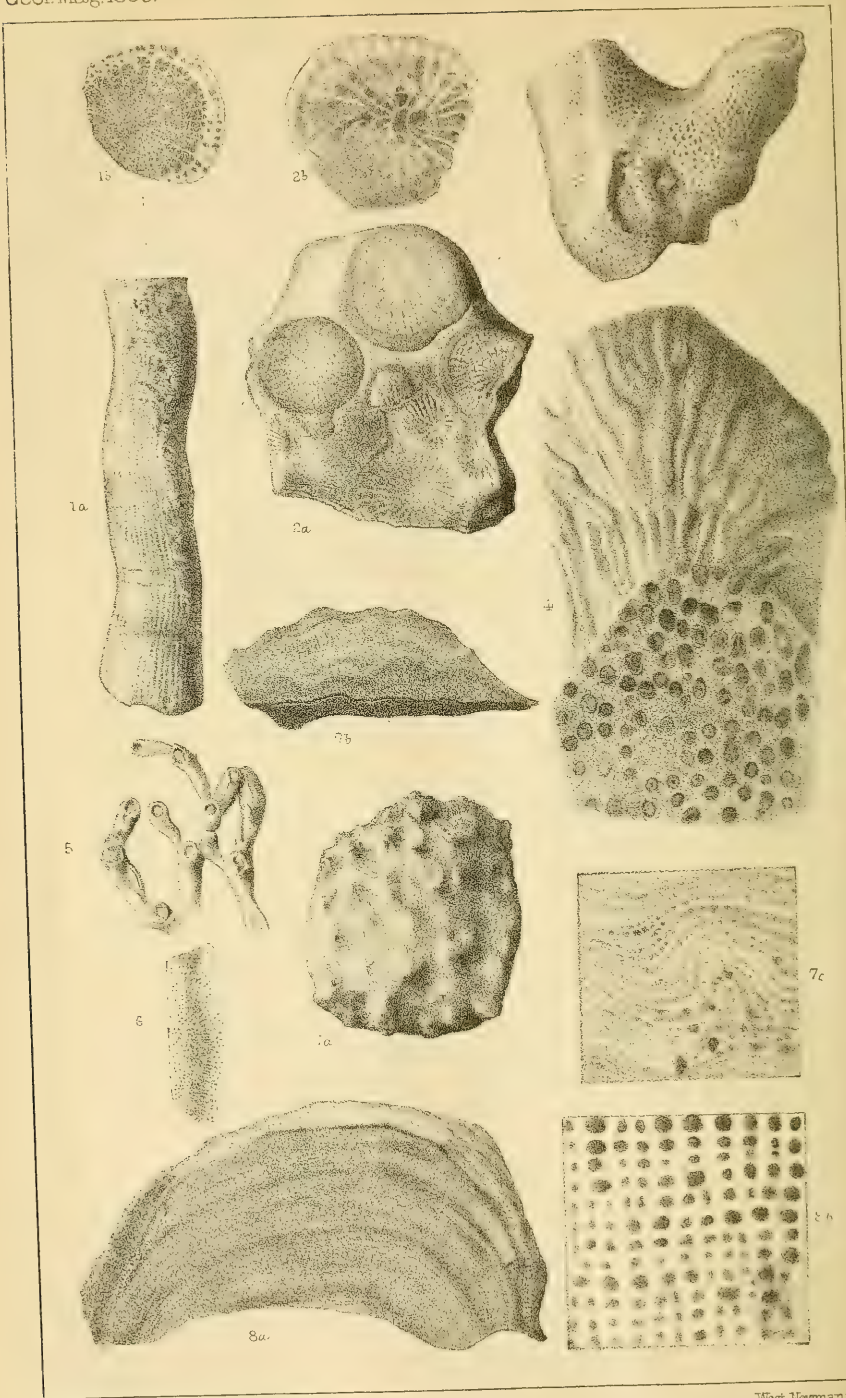
One word in conclusion—would Mr. Mellard Reade give his reasons for believing that waves ever cause surface particles in deep water to move in "an ellipse, not very different from one having the longer axis vertical"? I have heard this stated by a lecturer, who drew a vertical ellipse on the blackboard like the long eye of a bodkin; but I have never seen the statement in print except in Mr. Mellard Reade's paper above referred to (p. 338).

Southwood, Torquay. Arthur R. Hunt, F.L.S.

MISCELLANEOUS.

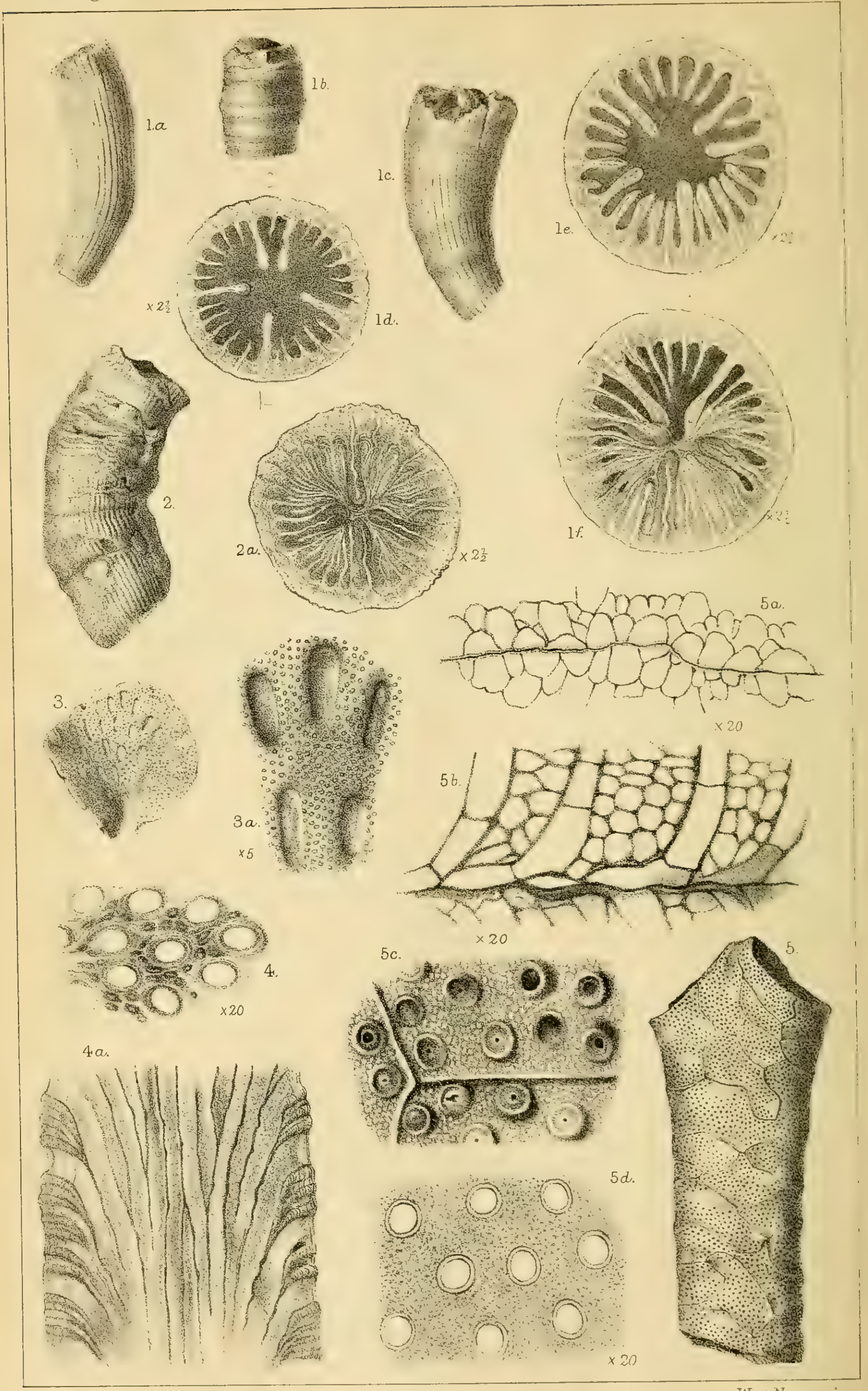
The Discovery of Coal at Shakespere's Cliff.—In February last Prof. W. Boyd Dawkins, F.R.S., announced that Coal had been reached in the experimental boring near Dover. A seam of coal of good bituminous character was reached at 1180 feet from the surface, 3 feet 6 inches in thickness, with a 4 inch parting of shale and sandstone in the middle.[1] The boring is to be continued for another 1000 feet, if necessary, to ascertain whether other beds of workable coal exist at a lower level.

[1] An oil-shale is also mentioned.



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

West Australian Fossils.



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

West Australian Fossils.

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ORIGINAL ARTICLES.

I.—Notes on the Palæontology of Western Australia.

(*Continued from the April Number*, p. 155.)

1. Stromatoporoidea. By Prof. H. A. Nicholson, M.D., F.G.S.

2. Corals and Polyzoa. By George J. Hinde, Ph.D., F.G.S.

[PLATES VIII. and VIII.a]

1. Stromatoporoidea. By Prof. H. A. Nicholson, M.D., F.G.S.

Actinostroma clathratum, Nich. Plate VIII. Figs. 8*a*, 8*b*.

Actinostroma clathratum, Nich., Ann. Nat. Hist. ser. 5, vol. xvii. p. 226, pl. vi. figs. 1–3; and Monogr. Brit. Strom. Pal. Soc. p. 131, pl. i. figs. 8–13, and pl. xii. figs. 1–5, 1889.

The specimen here figured is a typical example of *Actinostroma clathratum*. In all its general characters, and particularly in the regular development of the radial pillars and the presence of small astrorhizæ, it resembles the specimens from the Middle Devonian of Germany, which may be regarded as the normal form of the species. Very similar examples, however, occur in the Devonian Limestones of Devonshire. The surface of the specimen is not shown, being concealed beneath a crust of *Stromatoporella Eifeliensis*.

Locality.—Devonian, Rough Range, "opposite Mt. Krauss."

Stromatoporella Eifeliensis, Nich. Plate VIII. Figs. 7*a*—7*c*.

Stromatoporella Eifeliensis, Nich., Ann. Nat. Hist. ser. 5, vol. xvii. p. 235, pl. viii. figs. 5–7.

The specimen here figured (Figs. 7*a*, 7*b*) is a small example of the common *Stromatoporella Eifeliensis*, Nich., of the Middle Devonian rocks of Germany; and Fig. 7*c* gives a good general idea of the aspect of a vertical polished section as viewed under a lens. A crust of the same species covers the surface of the specimen of *Actinostroma clathratum* previously described, and of this three sections have been prepared. The structure of these agrees, in all essential respects, with that of sections of typical examples of *S. Eifeliensis* from Gerolstein, and need not therefore be described in detail. It is a remarkable and highly interesting fact that the Devonian deposits of Western Australia should have yielded examples of two such characteristic European Stromatoporoids as *Actinostroma clathratum* and *Stromatoporella Eifeliensis*.

Locality.—Rough Range, "opposite Mt. Krauss."

2. Corals and Polyzoa. By George J. Hinde, Ph.D., F.G.S.

Genus Amplexus, Sowerby.

Amplexus pustulosus, Hudleston.

1883. *Amplexus pustulosus*, Hudleston, Q.J.G.S. vol. xxxix. p. 591, pl. xxiii. figs. 1*a*–1*c*.

There are several compressed and crushed fragments of this species, which agree in every respect with the forms figured by Mr. Hudleston, save that they have none of the surface spines or nodes, from which the species derives its name. These processes, however, are not essential to the species, since they are not present on some of the figured type examples, which, through the kindness of Mr. Hudleston, I have had an opportunity of examining. The specimens, when uncompressed, are from 25 to 30 mm. in diameter. There are about 40 septa; at the summit of the calice they are 2 mm. apart, from centre to centre; lower down from 1·5 to 1·75 mm. In some instances in the lower portion of the coral, the septa become so thickened by sclerenchyma as to be laterally in contact. The outer surface, when unweathered, merely exhibits annulations of growth and fine epithecal striæ; the weathered examples show vertical lines and furrows, which are the exposed exterior margins of the septa.

Distribution.—Carboniferous Limestone, Gascoyne River.

Genus Cyathophyllum, Goldfuss.

Cyathophyllum virgatum, Hinde, sp.n. Plate VIII. Figs. 1*a*, 1*b*.

Corals simple (?), subcylindrical, elongated, straight or curved. About 56 septa, half of which are long and reach nearly to the centre of the calice; the others only reach from one-third to one-half that distance; there are about five septa in three millimètres. The septa are thick near their parietal margins, but somewhat rapidly diminish in size, and for the greater part of their length are very thin. They are connected by very stout dissepiments, which form a well-marked exterior zone to the calice. The wall is apparently formed by the lateral extension of the septa. The septa are apparently bilaminate, but the median line is not distinctly shown in sections. The outer surface of the coral is smooth or with faintly-marked longitudinal ridges, which correspond with the interspaces between the septa. When the surface is weathered, as in the specimen figured (Fig. 1*a*), the exterior margins of the septa appear as vertical lines connected by the dissepiments.

There are several imperfect examples of this species; the longest measures 70 mm. by about 11 in diameter. One specimen is partly covered by *Aulopora repens*. The specimens are now all simple, but it is not impossible that they may originally have formed fasciculate, compound colonies, like those of *Cyathophyllum cæspitosum*, Goldf. Though the character of the septa in this and the next species corresponds with that of the typical forms of the genus, it is doubtful whether the wall in these Australian forms is structurally similar to the Eifelian types; it is relatively much thicker than those with which I have been enabled to compare it.

Distribution.—Devonian (?). Opposite Mount Krauss, Kimberley District. Also from the Gascoyne River.

CYATHOPHYLLUM DEPRESSUM, Hinde, sp.n. Plate VIII. Figs. 2*a*, 2*b*.

Corallum compound, consisting of several subcylindrical corallites growing from a simple base: the individuals are for the most part free; when full-grown, about 17 mm. in diameter. There are about 58 septa, alternately large and small; some of the larger extend to the centre of the calice, and slightly curve round. The parietal margins of the septa are very thick, and there is an outer zone of thick dissepiments. The wall and septa of the same character as in the preceding species, from which it is distinguished by its mode of growth, the larger size of the corallites, and the stouter septa.

Distribution.—Devonian? Opposite Mount Krauss, Kimberley District. Another fragmentary specimen, partly incrusted by *Stromatoporella Eifeliensis*, Nicholson, is labelled from the Gascoyne River.

Genus PLEROPHYLLUM,[1] Hinde, gen. nov.

Syn. (?) *Pentaphyllum*,[2] De Koninck, 1872, preoccupied in 1821 for a genus of Coleoptera.

Generic Characters.—Simple, conical, turbinate or subcylindrical corals, with deep calices. There are usually five prominently developed septa (in some species only four), which reach nearly to the centre of the calice; the other septa are subequal. In the species with five prominent septa, the cardinal septum is small and is bounded on either side by a large septum, and the remaining three large septa represent the counter and alar septa. Where only four prominent septa are developed, one of them constitutes the cardinal septum. Both large and small septa exhibit a distinct opaque median lamina, which begins within the substance of the wall, and is inclosed by successive layers of stereoplasm, so that in the lower portion of the coral the septa are laterally in contact, and the interlocular and central areas are filled up with solid tissue. The wall of the coral is thick, and consists apparently of the coalesced parietal margins of the septa with an outer epithecal layer. The outer surface exhibits either shallow annulations of growth with fine concentric striæ, or longitudinal rugæ, or, more rarely, spinous projections.

I had at first placed the Australian Corals on which this genus is based in *Pentaphyllum*, De Kon., but it appears that this term had been previously employed, and as, moreover, some doubt[3] rested on the characters of the Belgian types, it seemed preferable to prepare

[1] πλήρης, full, in allusion to the way in which the corallum is filled up by stereoplasm.

[2] Nouvelles Recherches sur les Animaux fossiles du terrain Carbonifère de la Belgique, p. 58.

[3] For example, the main characteristic of *Pentaphyllum* is stated to be the possession of five prominent septa, but in the figure of the unique typical species, *P. armatum* (*l.c.* pl. iv. fig. 8*a*.), *six* are clearly shown; whilst in the only specimen of the other species included by De Koninck in this genus, *P. caryophyllatum*, there are but four prominent septa (*l.c.* pl. iv. fig. 9).

a new diagnosis. The genus nearest allied to *Plerophyllum* is *Anisophyllum*,[1] Edwards and Haime, founded on a small coral from the Devonian of Tennessee, in which only three prominent septa are developed, and these, according to Prof. Nicholson,[2] are the cardinal and alar septa. It is, besides, uncertain, whether the basal portion of the corallum in this genus is infilled by stereoplasm.

Plerophyllum australe, Hinde, sp.n. Plate VIIIa. Figs. 1*a*–1*f*.

Small conical, straight or curved corals, about 30 mm. in height, and from 10 to 14 mm. in diameter at the summit. The number of septa is usually 26; of these 5 are large and prominently developed, and 21 are smaller and subequal; sometimes there are two or three additional smaller septa. The cardinal septum is small, with a prominent septum on either side (Pl. VIIIa. Fig. 1*d*). Normally, this cardinal septum is on the dorsal or convex side of the coral; but in some instances the orientation differs, and this small septum between two larger is situated laterally (Figs. 1*e*, 1*f*). The counter-septum is large, and between it and the large alar septa there are on either side four or five smaller septa. The septa are but slightly developed at the summit margins of the calice; lower down the prominent septa extend to about two-thirds of the distance to the centre of the calice; their interior free margins are distinctly tumid or bulbous (Fig. 1*d*), and by successive additional layers of stereoplasm, they become still more so in the lower portions of the coral, until they meet and fill up the central area completely. The smaller septa vary considerably in size and in relative proportions to the larger. Within the calice they are often slender and extend only about one-third the distance to the centre (Fig. 1*d*); at a lower level in other specimens they are relatively much larger (Fig. 1*e*), and their free margins become bulbous by layers of stereoplasm, which finally unites them laterally, and they can then only be separately distinguished by their dense median lamellæ. The corals are not uniformly filled up at the same level with the stereoplasm, and possibly the spaces left vacant may be of the nature of fossulæ (Fig. 1*f*). The median lamellæ of the septa are sometimes curved and wavy; in the Figures (1*d*, *e*, *f*) they are represented by lighter lines as they appear by reflected light; in thin sections by transmitted light this central substance is opaque and dense.

The exterior surface of this species when well preserved is smooth, with delicate concentric epithecal striæ (Fig. 1*b*), but when weathered the median laminæ of the septa are shown as deeply impressed longitudinal lines or furrows (Figs. 1, 1*c*).

This species appears to be not uncommon, but the forms are all imperfect, and the calices are infilled with a hard matrix, so that the interior structures can only be studied from sections.

Distribution.—Carboniferous, Gascoyne River; Irwin River, Little Champion Bay, Victoria District.

[1] British Fossil Corals, Pal. Soc. 1850, p. lxvi. Polyp. foss. des terr. pal. p. 351, pl. i. figs. 2, 2*a*.

[2] Manual of Pal. 3rd ed. vol. i. p. 296.

Plerophyllum sulcatum, Hinde, sp.n. Plate VIIIa. Figs. 2, 2*a*.

Corallum curved, approximately subcylindrical, showing in the upper portion repeated renewals of growth. The only specimen, which is imperfect, is 40 mm. in height and 11 mm. in diameter. There are in all 28 septa, of which 4 are prominently developed and the others are subequal. The cardinal or dorsal septum is large; between it and the alar septa there are on one side 7, and on the other 8 smaller septa, whilst the large counter-septum has between it and the alar septa 4 smaller on one side and 5 on the other. The septa are about 1 mm. apart; they are of precisely the same characters as in *P. australe*, and they are similarly inclosed and consolidated by stereoplasm, so that in a transverse section of the lower portion of the coral the individual septa can only be recognized by their median lamellæ (Fig. 2*a*).

The outer surface in this species has well-marked longitudinal ridges and furrows about half a millimètre in width, which appear to be quite independent of the septa.

There is only a single example of this species in the collection. From *P. australe* it is readily distinguished by not having more than four prominent septa and by the different characters of the outer surface.

Distribution.—Carboniferous, Irwin River, Little Champion Bay, Victoria District.

Genus Pachypora, Lindström.

Pachypora tumida, Hinde, sp.n. Pl. VIII. Fig. 3.

Corallum branching; branches subcylindrical, tumid; ranging from 10 to 13 mm. in diameter. Corallites nearly circular in section; walls moderately thick, both in the central portions of the branches as well as near the surface; calices elongate-oval, subcircular or rhomboidal, about 1 mm. in diameter, moderately oblique to the surface. No septa or septal spines shown; tabulæ apparently few and complete; mural pores rare.

There is but one fragment of this species in the collection; it is about 40 mm. in length. The weathered upper surface shows the calices in fairly good preservation. From its surface aspect, this form would perhaps be regarded as belonging rather to *Alveolites* than to *Pachypora*; but judging from the thickened walls of the tubes, it may more properly be included in this latter genus. The calices however look much more like *Alveolites* than those of *P. cervicornis*, De Blainv., and they are larger and more oblique than in *P. meridionalis*, Nich. & Eth. jun. (Ann. & Mag. Nat. Hist. ser. 5, vol. iv. (1879) p. 280). On the other hand, the calices are less oblique and less regular than in *Alveolites* (*Cladopora*) *robusta*, Röminger (Fossil Corals, Geol. Surv. Michigan, p. 54, pl. 32, figs. 1, 2), which is regarded by Nicholson, though not with absolute certainty, as referable to *Alveolites*. As regards its mode of growth, *P. tumida* stands on the boundary-line between *Pachypora* and *Alveolites*.

Distribution.—Devonian? Opposite Mount Krauss, Kimberley District.

Genus SYRINGOPORA, Goldfuss.

SYRINGOPORA RETICULATA, Goldfuss, var. PATULA, var. nov. Pl. VIII. Fig. 4.

1826–33. *Syringopora reticulata*, Goldfuss, Petref. Germ. vol. i. p. 76, pl. xxv. fig. 8.
1852. *Syringopora reticulata*, Edwards and Haime, Brit. Foss. Corals, p. 162, pl. xlvi. figs. 1, 1*a*.
1872. *Syringopora reticulata*, De Koninck, Nouv. Rech. sur. les Anim. foss. pt. i. p. 123, pl. xi. figs. 7, 7*b*.
1879. *Syringopora reticulata*, Nicholson, Tabulate Corals, p. 215, fig. 30; and pl. x. fig. 5.
1880–1. *Syringopora reticulata*, Nich., Proc. Roy. Soc. Edinburgh, p. 225, fig. 3.

Corallum forming low bushy masses of cylindrical, flexuous radiating corallites, ranging in diameter from 1·6 to 2·15 mm. The largest specimen examined is 50 mm. in height by 110 mm. wide. The distance between the corallites varies from ·5 to 2 mm.; they are connected at irregular intervals, more by the interosculation of proximate corallites than by horizontal processes between them. The corallites also increase by frequent lateral buds given off from the stems, the young stems having the same general direction of growth as the parents.

The corallites have thick uniform walls about ·25 mm. in thickness; the septal spines appear to be irregularly developed, and reduced to small conical projections from the inner surface of the wall; in some transverse sections not more than three or four are visible, whilst in others there are five or six in about one-fourth the circumference of the corallite. The infundibuliform tabulæ are of the usual character, and there is no special infilling of sclerenchyma within the corallites.

I have ventured to place these specimens as a variety of *S. reticulata*, since, though the corallites are of about the same dimensions, they appear to increase more rapidly by lateral budding, and thus to diverge more in their mode of growth, and the connecting processes between them, if not altogether absent, are so reduced as to be scarcely distinguishable. The specimens are now imbedded in nodular masses of compact limestone, and their minute structural characters are very clearly shown in thin sections. The corallite walls consist, as pointed out by Prof. H. A. Nicholson (Proc. Roy. Soc. Edinburgh, 1880–1, p. 225), of two layers, an exterior, which is formed of compact sclerenchyma either granular or radiately fibrous, and an inner layer of concentrically arranged wavy fibres, which are interlaced together. In these Australian forms the exterior layer of the walls is of the same tint as the inner, and can scarcely be distinguished from it. It appears, however, to be present, and can be recognized in transverse sections as a thin outer zone of a granular character, whilst the inner layer is markedly of wavy fibres; there is, however, no definite line between the two layers. It is worthy of note that this wall-layer of wavy interlacing fibres seems to be very characteristic of *Syringopora* and its allies. In *S. Maclurei*, Billings, from the Devonian of Canada, the walls, which are very thick, appear to be wholly of this wavy structure, whilst in *Rœmeria minor*, Schlüter, from the Devonian of the Eifel, there is a well-marked exterior layer of radiating fibres, within which is the layer of wavy concentric fibres, thus corresponding in character to *S. reticulata.*

Distribution.—Gascoyne River. Not known whether Devonian or Carboniferous.

Genus Aulopora, Goldfuss.

Aulopora repens, Knorr and Walch. Pl. VIII. Fig. 5.

1775. *Milleporites repens*, Knorr & Walch, Recueil, etc., tome iii. p. 157, pl. vi. fig. 1.
1826–33. *Aulopora serpens*, Goldfuss, Petref. Germ. vol. i. p. 82, pl. xxix. figs. 1*a*.
1879. *Aulopora repens*, Nich., & Eth., jun., Ann. & Mag. Nat. Hist. ser. 5. vol. iv. p. 282.

There is a single example of this species growing on the surface of *Cyathophyllum virgatum*, which, as far as its outward characters are concerned, cannot be distinguished from the type forms of the species from the Eifel. The corallites range from 2·5 to 4·5 mm. in length, and from 1 to 1·25 mm. in thickness. The oval or elliptical apertures are between ·75 mm. and 1 mm. in width.

Distribution.—Devonian ? Rough Range, Mount Krauss, Kimberley District. This form has been already recorded by Messrs. Nicholson and Etheridge from the Devonian Limestone of Arthur's Creek, North Queensland.

ANNELIDA.

Genus Spirorbis, Daudin.

Spirorbis omphalodes, Goldfuss, sp.

1826–33. *Serpula omphalodes*, Goldf. Petref. Germ. pl. lxvii. fig. 3.

There are several specimens of a small *Spirorbis*, attached to the surface of *Cyathophyllum virgatum*, which appear to belong to the above species. They are about 2 mm. in diameter and ·75 mm. in height, the upper edge of the outer whorl is obtusely angular or rounded, surface apparently smooth.

Distribution.—Devonian ? Gascoyne River.

POLYZOA.

Genus Polypora, M'Coy.

Polypora australis, Hinde, sp.n. Pl. VIIIa. Figs. 3, 3*a*.

Polyzoary flabellate, dimensions uncertain. Branches nearly straight, radiating from the base and bifurcating at intervals of about 6 mm.; they are from 1 to 1·2 mm. in width, flattened, with the dissepiments on the same plane. The fenestrules are elongate oval, about 2 mm. in length by ·6 mm. wide, and about 2 mm. apart longitudinally. The cells are regularly arranged in quincuncial rows; there are five cells in an oblique row; the rows are continued across the dissepiments. The cell-apertures are circular, not apparently elevated, small, about ·15 mm. in diameter, and separated from each other by about their own diameters. The branches are about ·5 mm. in thickness. The reverse side of the frond is concealed by the matrix.

This species appears to be nearest allied to an Indian form, referred by De Koninck to *P. fastuosus* (Q.J.G.S. vol. xix. 1863, p. 5, pl. i. fig. 4); but it differs in the narrower fenestrules; the dissepiments are also larger and carry cells. Only a single fragmentary specimen known.

Distribution.—Carboniferous, Gascoyne River.

Genus HEXAGONELLA, Waagen and Wentzel.

HEXAGONELLA DENDROIDEA, Hudleston, sp. Plate VIII. Fig. 6 and VIIIA. Figs. 5–5*d*.

1883. *Evactinopora dendroidea*, Hudleston, Quart. Journ. Geol. Soc. vol. xxxix. p. 594, pl. 23, figs. 3*a*—3*d*.

1886. *Hexagonella dendroidea*, Waagen and Wentzel, Mem. Geol. Surv. India, ser. xiii. p. 913.

1889. *Evactinopora dendroidea*, R. Etheridge, jun., Proc. Linn. Soc. New South Wales, vol. iv. p. 207.

The examples of this species appear to be more abundant than those of any other fossil from the Carboniferous Limestone strata of the Gascoyne River, and the numerous specimens in the collection afford an excellent opportunity of ascertaining its minute characters. Since this form was described by Mr. Hudleston in 1883, several other species of the same genus have been recorded by Waagen and Wentzel from the Carboniferous strata of the Punjab, and these authors have proposed the new genus *Hexagonella* for their reception. As will be shown later on, the characters of this genus are so similar to those of *Fistulipora*, M'Coy, that it may be doubted whether it should be considered as more than a subgenus; but at the same time the species included in it possess in common some slight structural features, which make it desirable to place them in a distinct group, and I propose therefore to retain Waagen and Wentzel's name. Considerable interest attaches to this genus, since, according to these authors, it exhibits a mode of increase by so-called cœnenchymal gemmation, which, in their view, indicates distinctly that this and similar allied forms should be considered as Corals rather than Polyzoa. This evidence in favour of the cœlenterate nature of these organisms has been quoted by Prof. Nicholson,[1] and by the late Prof. Neumayr,[2] as strong proof of the correctness of the view that they are Corals. As the result of a careful study of numerous sections of the Australian species, which there can be no doubt is closely similar to the Punjab forms, I can find no indication of this alleged cœnenchymal gemmation, but, on the contrary, a mode of growth from a basal lamina which is strongly characteristic of Polyzoa, and as in other structural features these forms resemble Polyzoa, I accept this view of their character, which, it may be said is that originally held by Mr. Hudleston.

Hexagonella dendroidea occurs as solid, straight or curved stems or branches, ranging from 30 to 80 mm. in length, from 10 to 22 mm. in width, and from 5 to 15 mm. in thickness. The specimens are all fragmentary, the stems are usually compressed, sometimes nearly cylindrical, of an even width and thickness, except where

[1] Manual of Palæontology, third edition, vol. i. p. 352.
[2] Die Stämme des Thierreichs, p. 324.

they dichotomize (Plate VIIIA. Fig. 5). They are of a hard, greyish limestone, completely weathered out of the matrix; but the tubular cells and interstitial vesicles are partly infilled with chalcedony, and in part with calcite.

The outer surface of the branches is divided into irregular polygonal areas by raised lines or ridges, sometimes scarcely visible without a lens, at others elevated above the surface so as to form margins to depressed areas (Figs. 5, 5*c*). These ridges are given off from the angles of a zig-zag line, having a generally vertical direction on the narrow sides of the branch. The ridges pass indifferently across the cell areas and the maculæ, but they frequently meet in the centre of these latter. In weathered specimens these ridges are not recognizable, and they are not often visible in sections, unless tangential, where they appear as rows of bead-like dots, with dark centres and lighter borders, not unlike the spines in Monticuliporoids.

The surface of the branches is dotted over with maculæ; these are oval or subcircular spaces free from cells (Fig. 5); without definite boundaries, from 2 to 3 mm. in width, and from 5 to 8 mm. apart, from centre to centre. The maculæ are usually even with the general surface, though sometimes slightly below it. The general surface of the branches, both of the maculæ and of the areas between the cell-mouths, is, when well preserved, covered with microscopically minute blunted tubercles which appear to be solid and imperforate (Fig. 5*c*). As a rule, however, the branches are now smooth and imperforate.

The centre of the branches has a median lamina extending from end to end, from which the cells are given off. This axial lamina is double in character; in thin sections it appears as a dark line with a layer of lighter material on either side of it, the whole being about ·05 mm. in thickness. It seems to be quite imperforate (Figs. 5*a*, *b*).

The cells (= autopores) in this species are relatively long tubes, circular, elliptical, or oval in section (Fig. 5*d*); they commence their growth on the central lamina as conical tubes, semi-elliptical in section; in the first stage they are recumbent on the lamina for a distance of about ·75 mm., they then curve abruptly outwards and extend directly to the surface, to which they open nearly at right angles (Fig. 5*b*). The cell-walls are distinct from the interstitial substance, imperforate, of an even thickness throughout their length, not thickened near the surface, and in their upper portions apparently of concentric fibres. At irregular intervals, from ·25 to ·75 mm. apart, they are partitioned by complete tabulæ (Fig. 5*b*); but they are not infilled in any way with sclerenchyma. Measured in transverse section, the cells are from ·2 to ·25 mm. in diameter, but a few of the larger ones on the borders of the maculæ are ·37 mm. wide. The cell-walls are from ·03 to ·05 mm. in thickness; in some instances they exhibit a decided thickening or lip at one side; this is of a more opaque character than the rest of the wall (Fig. 5*c*). Beyond this thickening, there are no projections of the lip-margins within the cell or distinct trifoliation of the cell itself, as in many species of *Fistulipora*, and also in *Hexagonella lævigata*, Waagen and Wentzel (Pal. Indica, ser. 13, pl. 115, fig. 5).

On the surface of the branches, the cells are arranged in rows which radiate from the maculæ as centres. The cells in the rows are somewhat less than half a millimètre from centre to centre, and about the same distance between the rows. The cell-apertures are slightly oblique to the surface, and there is a distinct elevated lip, in some cases semilunate or crescentic in form (Fig. 5*c*). The cells near the maculæ are larger, more oblique, and with thicker lips than others.

As a rule, the cell-apertures are open, but in many instances the cells are partially or entirely closed by calcareous lids, placed just within the lip of the cell (Fig. 5*c*). These lids are flat or slightly convex, and usually incomplete, a central or sub-central space remaining open. In other cases this aperture is wholly closed by a minute central papilla. Occasionally the lid is evenly convex, and projects beyond the rim of the cell-wall. These lids appear to be distinct from the tabulæ in the lower portion of the cell; they are thicker; convex, instead of flat or concave; and they are frequently incomplete.

The spaces between the cells, where they radiate upwards to the surface from the axial lamina, are occupied by interstitial tissue or cancelli (= mesopores) (Fig. 5*b*). This is of two kinds; one, occupying principally the central portion of the branches, is mainly vesicular, and formed by convex vesicles arranged sometimes in linear series, sometimes irregularly overlapping and dovetailing into each other (Fig. 5*b*). The peripheral portions of the branches on the other hand mainly consist of a solid imperforate tissue deposited in thin concentric zones. Occasionally, however, there is a layer of vesicles within the exterior solid zone, and sometimes a thin solid band intercalated in the central vesicular area. The solid substance does not, however, seem to be a mere infilling of the vesicles; but it is of a distinct character replacing the vesicles. On polished surfaces, and in sections viewed by reflected light, this substance can be seen to consist of delicate rods or spines vertically arranged and imbedded in a lighter material, and it appears that the minute tubercles with which the surface is covered are the upward extensions of these bodies. In transparent, transverse sections, this solid tissue has an indistinct cloudy appearance, due to innumerable, opaque dots—the section of the rods—in a lighter substance (Fig. 5*d*). The thickened portion or lips of the cells likewise consists of these solid spines or rods.

No mention is made of this solid interstitial tissue in the Punjab species of *Hexagonella*, but it is shown in the figures of *H. ramosa* (Pal. Indica, ser. 13, pl. 107, fig. 3*c*). Similar tissue is likewise present in certain specimens of *Fistulipora incrustans*, which have been described by Mr. John Young, F.G.S. (Ann. & Mag. Nat. Hist. April, 1888, p. 245), and in *Goniocladia cellulifera*, R. Eth., jun. (Geol. Mag. Dec. I. Vol. X. p. 433, Pl. XV.)

The general question as to the relation of *Hexagonella* or *Fistulipora* to Polyzoa or Corals is too wide to be properly discussed here; but there is no doubt that the alleged cœnenchymal gemmation—the special point brought forward by Waagen and Wentzel in favour of the alliance of these forms to Corals—certainly does not take place in *H. dendroidea*, and there is no satisfactory evidence that it occurs in the Indian species of the genus described by these authors. They further appeal to the figure given by Nicholson and Foord of *Fistulipora incrustans* (Ann. and Mag. Nat. Hist. ser. 5, vol. xvi. p. 501) as showing the same mode of increase by cœnenchymal gemmation; but it is evident that the figure referred to gives no indication of the development of the cells or autopores from the mesopores; it merely shows that the former have been sectioned obliquely. The real origin of the cells or autopores in this species is by growth from the basal lamina, precisely in the same manner as in *Hexagonella dendroidea* described above.

This species was originally placed by Mr. Hudleston in the genus *Evactinopora*, Meek and Worthen, but it has no close relationship to *E. radiata*, the type of this genus. It appears to me very doubtful whether the form named *H.* (*Evactinopora*) *crucialis*, Hudleston, is really distinct from *H. dendroidea*, as the difference consists merely in the mode of growth, a feature hardly of specific importance. *H. ramosa*, W. & W., though similar in mode of growth to *H. dendroidea*, has its cells only about half as large as in the latter species, and is consequently distinct.

Distribution.—Carboniferous, Gascoyne River.

Genus Rhombopora, Meek.

Rhombopora tenuis, Hinde sp.n. Pl. VIIIa. Figs. 4, 4*a*.

Imbedded in some pieces of rock from the Gascoyne River are several fragments of a small branching polyzoon, which in microscopic characters are similar to the genus *Rhombopora*. The specimens are cylindrical and branching, about 1·5 mm. in diameter; the cells spring from an imaginary central axis, and at first are nearly vertical or slightly oblique; they then curve somewhat abruptly and open approximately at right angles to the surface of the branch (Fig. 4*a*). In the axial portions the cells are subcircular in section, with thin walls; at the point where the outward curve commences, the walls are considerably thickened. The cell-apertures are oval, about ·2 mm in width with definite fibrous margins; in the interspaces between them there are well-marked interstitial tubes and spines (Fig. 4). I have not recognized any tabulæ in the cells.

From a comparison with specimens and sections of *Rhombopora interporosa*, Phill. sp., kindly supplied me by my friend Mr. John Young, F.G.S., I find a very close resemblance in microscopic structure to the Australian species; at the same time there is also a certain resemblance to such forms as *Monticulipora ? tumida*, Phill. sp., and more particularly to a slender variety of this species from the Carboniferous strata of Northumberland, which has been named var. *miliaria* by Prof. Nicholson (Genus *Monticulipora*, p. 123, pl. iii. figs. 2, 2*c*).

Distribution.—Carboniferous, Gascoyne River. The specimens are associated in the same matrix with *Hexagonella dendroidea*.

EXPLANATION OF PLATES VIII. AND VIIIA.

PLATE VIII.

FIG. 1.—*Cyathophyllum virgatum*, sp.n.; 1*a*, a fragmentary specimen, natural size; 1*b*, transverse section enlarged two diameters.

,, 2.—*Cyathophyllum depressum*, sp.n.; 2*a*, the upper surface, showing the weathered summits of the corallites; 2*b*, a transverse section, enlarged.

,, 3.—*Pachypora tumida*, sp.n., natural size.

,, 4.—*Syringopora reticulata*, var. *patula*. Portion of a specimen, showing the corallites in section. Natural size.

,, 5.—*Aulopora repens*, Knorr and Walch.

,, 6.—*Hexagonella dendroidea*, Hudleston, sp. A section showing the thickness of the branch.

,, 7.—*Stromatoporella Eifeliensis*, Nicholson; 7*a*, 7*b*, specimens natural size; 7*c*, vertical section enlarged.

,, 8.—*Actinostroma clathratum*, Nicholson; 8*a*, vertical section natural size; 8*b*, portion of the same enlarged.

PLATE VIIIA.

FIGS. 1–1*f*.—*Plerophyllum australe*, Hinde.

,, 1*a*, 1*b*, 1*c*.—Three imperfect examples natural size; 1*b* shows the exterior surface in its natural condition; in 1*a* and 1*c* the surface has been weathered, and the median laminæ of the septa are exposed.

,, 1*d*.—A transverse section of the calice, with the small cardinal septum inclosed between two larger septa above. Enlarged 2½ diameters.

,, 1*e*.—A transverse section of another specimen, similarly enlarged, in which the smaller septa are proportionately more developed, and the small septum between the two larger is lateral in position.

,, 1*f*.—Another transverse section, similarly enlarged, in which one portion has been completely infilled by stereoplasm.

,, 2, 2*a*.—*Plerophyllum sulcatum*, Hinde.

,, 2.—An imperfect specimen, showing renewals of growth and the longitudinal rugæ of the surface.

,, 2*a*.—A transverse section of the same, enlarged 2½ diameters, showing complete solidification by stereoplasm.

,, 3, 3*a*.—*Polypora australis*, Hinde.

,, 3.—A fragmentary specimen showing the celluliferous surface, natural size.

,, 3*a*.—A portion of the same, enlarged 5 diameters, showing the form and disposition of the fenestrules and cell-apertures.

,, 4, 4*a*.—*Rhombopora tenuis*, Hinde.

,, 4.—A portion of the surface showing the cell-apertures and the interstitial tubes and spines. Enlarged 20 diameters.

,, 4*a*.—A portion of a longitudinal section, showing the disposition of the cells and the thickening of the walls near the surface.

,, 5—5*d*.—*Hexagonella dendroidea*, Hudleston, sp.

,, 5.—An imperfect stem or branch, showing the mode of growth, the linear ridges, the maculæ, and the cells of the exterior surface. Natural size.

,, 5*a*.—A portion of a transverse section of a branch, showing (in section) the median layer and the cells (=autopores) on it. Enlarged 20 diameters.

,, 5*b*.—A portion of a median longitudinal section of a branch, showing the recumbent position of the cells on the median layer in their first stage of growth, their subsequent vertical direction, the tabulæ traversing them at intervals, and the vesicular interstitial tissue of the central area. Enlarged 20 diameters.

,, 5*c*.—A portion of the surface of Fig. 5, enlarged 20 diameters, showing the oblique projection of the lips of the cells, the manner in which they are partially or entirely closed by calcareous lids, the tuberculate character of the interstitial areas, and the raised ridges.

,, 5*d*.—A portion of a tangential section, showing the cells with distinct walls, and the cloudy appearance of the solid interstitial substance of the outer zone of the branch. Enlarged 20 diameters.

II.—On some Epi-diorites of N.W. Ireland.[1]

By J. Shearson Hyland, Ph.D.

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

In an Appendix to the Explanatory Memoir on Sheet 17 of the Map of the Geological Survey of Ireland (Dublin, 1889), I have furnished a description of the petrographical characters of the Epi-diorites of the district. Some of the facts elicited by the examination of the rocks are sufficiently interesting to deserve a wider circulation.

The rocks occur as sheets and dykes intrusive into the altered sediments (quartzites, mica-schists,[2] etc.), and at St. Johnstown and Raphoe they are seen to break through the stratified deposits transversely to the bedding.[3] In the field, a strong foliation is often to be recognized; but this structure is at times little developed and hardly perceptible. Still the absence of this macroscopic feature does not preclude the possibility of reconstruction having occurred; for it has been abundantly demonstrated that molecular re-arrangement can ensue without the development of such a structural modification.[4]

The specimens examined are greenish in hue and vary in grain from coarse to fine. The petrographical description is mainly based upon a collection made from the following localities:—

One mile N. of Raphoe; Half mile N. of Raphoe; Half mile N. of Convoy;	Co. Donegal.
Half mile S.E. of Drumahoe Bridge, and two miles S.E. of Derry; One mile and a half W. of St. Johnstown (Dooish Mountain); One mile and a half S.S.W. of New Buildings, and four miles S.S.W. of Derry;	Co. Londonderry.

The rocks described under the head "Epi-diorites" are plagioclase-pyroxene rocks which have undergone alteration under the influence of dynamic metamorphism. Most of them were originally dolerites (Ger. *Diabase*); but it is not improbable that the masses at one mile N. of Raphoe and half mile N. of Convoy represent altered gabbros.

As a result of the metamorphism, the pyroxene has been completely altered into a greenish monoclinic hornblende, which possesses the characters of "uralite." This mineral occurs in ragged patches, which in most cases still preserve the ophitic structure of the pyroxene which it has replaced. Where there has been movement coincident with or subsequently to this uralitization, the horn-

[1] Read before the Royal Geological Society of Ireland, 10th February, 1890.

[2] The dark bluish-grey mica-schist is seen under the microscope to consist of a plexus of light-green, uniaxial mica and minute grains of quartz. Calcite, hematite, tourmaline, and rutile are also present. Strain-slip cleavage is well developed. Iron-pyrites is to be observed macroscopically, also rutile according to Giesecke.

[3] Prof. Hull in Memoir to Sheet 17, p. 7.

[4] Teall, "The Metamorphosis of Dolerite into Hornblende-schist," Q.J.G.S. 1885, p. 139, and "The Metamorphosis of the Lizard Gabbros," Geol. Mag. Dec. III. Vol. I. p. 487.

blende becomes split up into innumerable fibres which partake in the general movement. A sort of lenticular structure is thus produced, the margins of the lenticles consisting of a felted hornblendic mass in a state of fine division. In the much altered varieties, the hornblende becomes decidedly actinolitic in character, forming long green or bluish-green prisms. As the actinolitic nature becomes the more evident the more decided the foliation, it is not surprising that planes of movement are coated with amianthus-like actinolite (one mile S.S.W. of New Buildings, Co. Derry). Liebe[1] has described the presence of primary hornblende in rocks of this type; but there is no evidence of an occurrence of this nature in those under examination. A colourless, tremolite-looking hornblende is sometimes apparent, but is not a constant accessory.[2]

Intergrown with and imbedded in the hornblende there are to be observed numerous patches and flakes of biotite. This mineral is singularly devoid of inclusions, and appears to stand in a genetical relation to the hornblende. The pleochroism is:—

α = pale straw colour.
β and γ = brownish-yellow to dark-brown.

Epidote and zoisite[3] are very common, whilst secondary quartz is not infrequent. There is also a little calcite present. The quantity of felspar varies more or less, but is always subordinate to that of the hornblende. It can eventually become very small, as the hornblende appears to displace the felspathic constituent. This almost entire disappearance of the felspar may account for the statement made over fifty years ago by G. Rose, that "uralite" was only to be found in those greenstones in which felspar was absent or little apparent.[4] Still, notwithstanding this opinion, put forth shortly after his discovery of the mineral, mention is especially made in his work on the Urals of the constant association of uralite and oligoclase.[5]

The metamorphism of the felspar leads to its "granulation," and the consequent formation of new products. This "granulation" is referred to a "crystallizing process going on under the influence and

[1] Uebersicht ueber den Schichtenaufbau Ostthüringens, Abhandl. zur geol. Spezialkarte von Preussen u. d. Thüring. Staaten, Band V. Heft 4, p. 83.

[2] Tremolite occurs in the district comprised in Sheet 17, viz. near Curley Hill, Co. Tyrone, but in limestone. (C. L. Giesecke, Minerals of the Royal Dublin Society, to which is added an Irish Mineralogy, Dublin, 1832, p. 227.)

[3] For crystallographic details, see Memoir, Sh. 17, pp. 35 and 36. The occurrence of zoisite in this district, at Holly Hill, near Strabane, Co. Tyrone, was known to Portlock (Report of the Geology of the Co. Londonderry, etc., Dublin, 1843, p. 209); also to Giesecke (*loc. cit.* p. 208).

[4] Pogg. Ann. d. Ph. 1833, 1 St. p. 103. "Immer aber haben sie (Uralite) sich nach den gemachten Erfahrungen nur in den Grünsteinen gefunden in welchen Albit oder Feldspath nicht vorkommen oder wenigstens nicht deutlich ausgeschieden vorkommen; mit der Bildung dieser Mineralien scheint die Bildung des Uralits aufzuhören und statt dessen *Hornblende* an seine Stelle zu treten." The term "uralite" is used in a strict sense as applying to a mineral possessing the outer form of augite and the cleavage planes of hornblende (V. Pogg. Ann. 1831, xxii. p. 321; and Jahrb. f. Min. 1832, p. 237).

[5] "Reise nach d. Ural," Band II. 575.

control of powerful mechanical stresses."[1] The original felspathic constituent was a labradorite. Some few well-developed lath-shaped sections, parallel to the M-face, give an extinction of $-30°$; this denotes the presence of a felspar allied to $Ab_1\ An_3$. Such sections show the albitic lamellation. The mass of the felspar is, however, particularly striking owing to the want of this striation, to its granular condition, and to its occurrence in conjunction with quartz and epidote. This combination of minerals forms under crossed Nicols the so-called "quartz-felspar-(epidote)-mosaic": it bears every aspect of being secondary, and recalls the metamorphism of labradorite ($Ab_1\ An_2$ according to Schilling[2]) into albite with bye-products, as has been described by Lossen in the case of the Hartz diabases.[3] The similarity being so strong, we may therefore assume that a like alteration has been effected in the felspar of our Irish Epi-diorites.

The albitic character of the secondary felspar has been inferred from the analyses of the vein-felspars so frequently observed in rocks of this class. Gümbel[4] supplies, for instance, an analysis of a vein-"albite" from the Fichtelgebirge, whilst Teall[5] gives the composition of the vein-felspar in the Scourie Dyke in Sutherlandshire as that of andesine. From his analysis I have calculated the admixture of orthoclase, albite, and anorthite to be as follows:—

			Orthoclase. 10·40%		Albite. 59·06%		Anorthite. 28·78%
SiO_2	58·16	=	6·72	+	40·54	+	12·42
Al_2O_3	26·66		1·92		11·53		10·57
CaO	5·79		—		—		5·79
MgO	·65		—		—		—
Na_2O	6·99		—		6·99		—
K_2O	1·76		1·76		—		—
	100·01		10·40		59·06		28·78
			2·4				1

This would represent a felspar of the constitution An_1, $Ab_{2·4}$, *i.e.* a felspar intermediate between andesine and oligoclase.

It would manifestly be more accurate to analyse the felspar which occurs in the ground-mass of the rock itself; but no attempt has apparently been made in this direction owing to the difficulties the isolation presents. In order to do this, the rock from Convoy was taken, and, after being powdered, treated with weak acid in order to remove the small quantity of calcite present. The secondary felspar was then separated by means of the Sonstadt-solution: its specific gravity was found to be 2·645. The analysis gave the following result:

[1] Judd, "On the Processes by which a Plagioclase Felspar is converted into a Scapolite," Min. Mag. viii. No. 39, p. 186 (13).

[2] "Grünsteine des Harzes," Göttingen, 1869.

[3] "Studien an metamorphischen Eruptiv- und Sedimentgest," Jahrbuch d. k. preuss. geol. Landesanstalt für 1883, Berlin, pp. 619–640. Also, Erläuterungen zur geol. Specialkarte von Preussen, Blatt Wippra, 1883, pp. 50 and 83.

[4] "Die paläolithischen Eruptivgesteine des Fichtelgebirges," München, 1874, p. 14.

[5] British Petrography, p. 155.

				Orthoclase. 2·11%		Albite. 71·49%		Anorthite. 22·31%
SiO_2	62·86	=	62·74	= 1·36	+	49·07	+	9·63
Al_2O_3	20·1		20·06 }	0·39		13·96		8·19
*Fe_2O_3	2·6		2·59 }					
CaO	4·5		4·49	—		—		4·49
K_2O	0·36		0·36	0·36		—		—
Na_2O	8·48		8·46	—		8·46		—
H_2O	1·3		1·3	—		—		—
	100·20		100·00	2·11		71·49		22·31
				3·3				1

The constitution of the secondary felspar may be considered as $An_1\ Ab_{3\cdot3}$. The molecular rearrangement of the original labradorite ($Ab_1\ An_3$) has resulted in the formation of a felspar allied to oligoclase. We have accordingly the association of uralite and oligoclase in the rocks, and it is hence interesting to recall G. Rose's observations upon the subject. (*Vide supra.*)

Owing to this alteration of the felspar, a large amount of lime was set free, which induced the formation of epidote and zoisite. The aggregates of these two minerals are sometimes found piercing the bi-silicate in continuous lines, and thus preserve the ophitic structure so characteristic of dolerites.

Iron-pyrites and ilmenite are present: the latter is mostly altered into granular aggregates of sphene. The amount of chlorite and quartz is naturally in direct proportion to the degree of alteration the rock has undergone. Apatite is rare.

There is no evidence of the presence of either scapolite or sahlite in the specimens examined. It is, however, highly probable that both these minerals are to be met with in the greenstones of this district, as Sir Charles Giesecke records their occurrence at the old lead-mine in the neighbourhood of Strabane, Co. Tyrone.[1] The scapolite shows a "four-sided prism"; whilst the sahlite is described under the old name "baikalite." The same mineralogist calls attention to the presence of "silver-white, pearly mica, resembling lepidolite," at Holyhill, Co. Tyrone, where he also observed lievrite.

14, *Hume Street, Dublin.*

III.—The High Continental Elevation preceding the Pleistocene Period (in America).

By Prof. J. W. Spencer, A.M., Ph.D., F.G.S.,
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(Read before the Geol. Soc. Am., August, 1889.)

If, in the growth of the American continent, the moulding of the land features had not largely depended upon its projection above the sea, favouring or retarding the action of rains and rivers,

* The Fe_2O_3 was estimated by titration: the amount is certainly high; but the sp.g. of the powder (2·645) shows that it cannot be ascribed to the presence of epidote. 2·59% of Fe_2O_3 would be equivalent to an admixture of about 5·8% of epidote, which would demand a sp.g. of about 2·9 (*cf.* Cathrein, "Ueber Saussurit," Zeits. f. Kryst. vii. 241–242).

[1] *loc. cit.* pp. 208 and 219.

in sculpturing its surface, there would be little interest as to what was its relative height, before the commencement of the Pleistocene period. But we find valleys vastly greater than meteoric agents could have produced under existing circumstances. Thus, there are not only deep *cañons*, but also vast depressions, descending to levels far below the sea, which are now filled with the earlier drift accumulations, or form channels submerged beneath ocean waves, or constitute basins occupied by lakes. Hence, in the study of the drift itself, in the investigation of the lake history, or in the research upon the growth of modern rivers, we necessarily inquire what was the altitude of the continent that would permit of the mouldings and channellings of the original rock surfaces.

Following the period of high continental elevation, the geologist sees in the valleys and old channels, still below the level of the sea, and in the high level beaches, an extensive submergence, succeeded by a re-elevation, but not to the original height, when the continent was being chiselled out by the ancient rivers. That this re-elevation is still going on is shown by the northward tilting of the comparatively recent marine accumulations, along the St. Lawrence valley and gulf coast, and the raised beaches in the Lake region, as well as by the shoaling of the waters of Hudson Bay during the present period of observation.

As general statements do not satisfy investigation, it becomes necessary to search for definite measurements of the former height of the continent among the archives of the geological past. Let us first seek for the testimony recorded by the Mississippi River.

For the distance of eleven hundred miles, measured in a direct line, above the mouth of the "Father of Waters," the modern valley is merely maintaining its own size, or more generally is being slowly filled by the deposition of river alluvium upon its floor. There are only two exceptions, of a few miles each, where the river is scouring out the rocky floor, and these are over barriers recently exposed, during changes of the Pleistocene period. To such an extent has the ancient valley or *cañon* been filled, first with drift, and this covered with river alluvium, that its original rocky floor is now buried to a depth of 170 feet,[1] even at La Crosse, a thousand miles from the Gulf of Mexico. Farther south, the depth of these loose deposits increases, until at New Orleans a boring of 630 feet[2] below sea-level does not penetrate the southern drift, nor even reach to its lowest members. The lower 500 miles of the ancient Mississippi were excavated out of Eocene or Cretaceous deposits, whilst the valley above the mouth of the Ohio has the form of a *cañon* excavated out of Palæozoic rocks, varying in width from two or three to ten miles, and having a depth (exclusive of the nowfilled portion) of from 150 to 550 feet.[3]

From this inspection of the river, it is easily seen that no natural

[1] Geol. Wis. vol. i. p. 253.
[2] Prof. E. W. Hilgard, Am. Journ. Sc., Nov. 1869, p. 333.
[3] Val. Min. and Miss. to Junct. of Ohio; Gen. G. K. Warren, Rept. Eng., U.S.A., 1878.

rainfall could so increase the volume of the discharge as to remove all the deposits which now fill the old valley, much less excavate the original and immense *cañon*. A vastly greater elevation of the continent would be necessary. Even were the whole continent uniformly elevated 630 feet together with the remainder of the unknown depth of the ancient Mississippi River at New Orleans, the *cañon* of the upper part of the river would require a still greater relative elevation of the northern country, in order to give sufficient channelling power to the flowing waters. But the slope of the floor of the buried valley is much less than that of the modern one, as was formerly shown by the author.[1] Here, again, is the proof that the country drained by the upper waters of the Mississippi once stood much higher than at present, relatively, to that of the region nearer its mouth. Of the amount, which was at least many hundreds of feet, we have no absolute measurement. Nor can we ascertain it by calculation, for there is no registry of the excess of the amount of rainfall, during the epoch of the greatest sculpturing, over that of the present day.

Whilst these records of the Mississippi, which have been only partially deciphered, do not furnish all the desired information, yet, as far as they go, they are invaluable.

Passing from the buried channel of the Mississippi to its continuation, now submerged beneath the waves of the Gulf of Mexico, we find evidence indicating such a stupendous continental elevation as to be almost incredible were it not supported by collateral evidence, upon both the Pacific and Atlantic coasts. The soundings off the coast of the delta of the Mississippi indicate the outer margin of the continental plateau as submerged to a depth of 3600 feet,[2] indented by an embayment of another hundred fathoms in depth, at the head of which there is a valley, a few miles wide, bounded by a plateau from 900 to 1200 feet above its floor. This valley is now submerged to a depth of over 3000 feet, and is the representative of the channel of the ancient Mississippi River, towards which it leads.

On the Pacific coast, in the region of Cape Mendocino, Prof. George Davidson has identified three valleys now submerged to from 2400 to 3120 feet, and several of inferior depth. These measurements are those of the valleys where they break through the marginal plateaux of the continent, at about six miles from the present shore, where it is submerged to the depth of a hundred fathoms.[3]

The soundings along the Atlantic coast reveal similar deep fjords. The extension of the Hudson River beneath the Atlantic waters, known long since, is traceable to the margin of the continental acquiring a depth of 2844 feet, in front of which the soundings plateau, show a bar, covered with mud, which, however, is now submerged to the depth of only 1230 feet.[4]

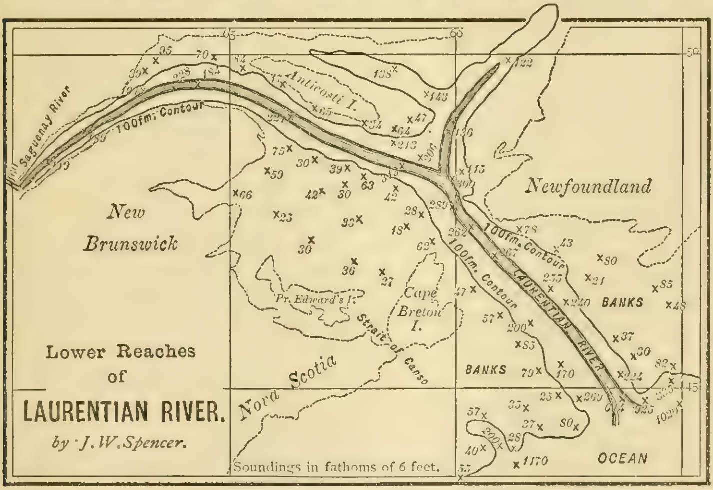
The as yet unpublished soundings off the mouth of the Delaware

[1] J. W. Spencer, "Warping of the Earth's Crust," etc., Am Nat., Feb. 1887.
[2] J. W. Spencer, "The Miss. River, etc." 1884. See also Coast Survey Charts.
[3] Prof. George Davidson, Bull. Cal. Acad. Sc., ii. 6, 1887, p. 265.
[4] A. Lindenkohl, Appendix, No. 13, Rept. U.S. Coast Survey, 1884, pp. 270-273.

River bring to light another valley, the floor of which is now covered by ocean waves to nearly 1200 feet—its continuation seaward not having been ascertained.

Were the continent elevated only 600 feet, the Gulf of Maine would be replaced by a terrestrial plain, in some places 200 miles wide, but traversed by rivers, one of which towards its mouth would be 2064 feet deep, that is to say, the bottom of the fjord is now submerged 2664 feet. Even this great depth may not be its maximum, for along the line between the opposite banks, at the mouth, now beneath a hundred fathoms of water, we find that the sea is nearly 5000 feet deep. Whether this represents an embayment of the ocean, setting towards the valley, or a continuation of the fjord, is not determined.[1]

The St. Lawrence River and Gulf bear the same testimony to the existence of deep fjords extending from the rivers through the now submerged plateau forming the margin of the continent. The lower part of the Saguenay River flows between stupendous walls, and constitutes a fjord whose waters reach a depth of 840 feet. In the



St. Lawrence River, a little below the mouth of the Saguenay, there is a channel 1134 feet below the surface. This increases in depth in passing seaward. In the region of the centre of the modern gulf the floor of the old channel is now submerged 1878 feet, and the adjacent valley 1230 feet, thus showing the *cañon* as being over 600 feet deep. As at the mouth of the channel through the Gulf of Maine, so at the mouth of that of the St. Lawrence, there is a deep chasm, for enclosed between the banks, a hundred fathoms below the surface, there is now the depth of 3666 feet, with water 2000 feet deeper just seaward of it. Although this ancient valley is over sixty miles wide at its mouth, with a narrower channel, yet it is not as broad as some portions of the modern so-called river. The

[1] U.S. Coast Survey Charts.

breadth of the submerged valley throughout its windings for a length of 800 miles or more, is remarkably regular, only gradually increasing its magnitude in passing seaward. Other lesser channels are visible in the soundings; thus south of the Straits of Canso, between Nova Scotia and Cape Breton Island, there is one 1200 feet deep, where adjacent soundings show less than 600 feet of water.

Hudson Bay rarely exceeds a depth of 600 feet, yet at the outlet, the channel is 1200 feet deep. This depth increases in passing down the Straits, where the scanty soundings show 2040 feet, before reaching the mouth. Here, in Hudson Straits, the old valley is a chasm across a mountain system, whose peaks, upon the southern side, rise to 6000 feet above tide. The *cañon* of the St. Lawrence also crosses the trend of two mountain systems, but these are of no great height. The same is not true for any of the other submarine valleys described.

The record of a former high continental elevation is again inscribed in the depths of the Great Lakes—Ontario reaching to 491 feet below ocean-level; Superior to nearly as much; Michigan to 300; and Huron to 150 feet. The lake basins are merely closed-up portions of the ancient St. Lawrence valley and its tributaries. Their distance from the sea would necessitate not merely a general elevation of the continent, but also a greater amount of elevation towards the head-waters of the system, as has been shown with regard to the excavation of the upper portion of the ancient Mississippi *cañon*. The lake-basins are all excavated out of Palæozoic rocks, except a part of that of Lake Superior.

The soundings do not afford all the information that we desire. yet they demonstrate the presence of submarine valleys reaching upon all our coasts to depths of more than 3000 feet. Again, the soundings show that to within comparatively short distances from their mouths, the depths of the valleys below the surface of the seas sometimes did not exceed from 1200 to 1800 feet, but that beyond there was a great increase in depth within the last few leagues.

Whilst depressions in the earth's surface are made and modified by terrestrial crust movements, yet the leaving open of great yawning chasms is not of sufficiently well-known occurrence to attribute all the submerged valleys upon the American coasts to such an origin, especially when we consider the great length of the submerged channel of the St. Lawrence River (800 miles), its various windings, and its uniformly increasing size, until it passes into the great chasm, just before it reaches the margin of the continent.

The idea of the excavation of these submerged valleys by glaciers, some of which are outside of glacial regions even of the past, is too untenable for a moment of serious consideration. Irrespective of the causes which have determined the location of the channels, here described, it appears that they have been made one and all by the excavating power of rivers and lateral streams pouring down the hill-sides. These, together with other meteoric agents, have also to a greater or less extent removed the Palæozoic and the Triassic rocks, from the depressions now occupied by the Gulfs of St. Lawrence and Maine, which have, however, been more or less affected by terrestrial movements.

The length of time required to excavate the channels of these great rivers commenced as far back as the Palæozoic days. However, the culmination of that of the Mississippi was not until in the later Tertiary, before the Pleistocene period. As the St. Lawrence, now submerged to a depth of over 1200 feet for a distance of 800 miles, is mostly cut out of rocks of the Palæozoic group, except a belt of the Triassic (across the lower portion, more or less involved in mountain uplifts), its antiquity must be very great. The culmination was also probably in the later Tertiary era, like that of the Mississippi, and the channels on the California coast, for there are submerged Tertiary rocks off the coast of Massachusetts and Newfoundland, at elevations much higher than the beds of the old channels.

Although the excavating forces took so many periods to form the valleys, and required a high continental elevation, yet the extreme altitude of over 1800 feet appears to have been of comparatively short duration, for otherwise the deep chasms in which the submerged channels terminate would have extended farther inland than we find them, and would have been headed by more gentle slopes, in place of precipitous cliffs, over which the waters of the former rivers were precipitated in great cascades. In the fjords of Norway, merging into rapidly contracting valleys, or headed by great vertical walls, hundreds of feet in height, having the structure named *cirques*, may be seen to-day the counterpart of the coast of the American continent, when its marginal plateaux stood over 3000 feet higher than at present; yet Norway stood once much higher than now, but was afterwards submerged, from which depression it has only recently been re-elevated so that its plateaux, close upon the sea, rise to three or four thousand feet, and its mountains still higher.

The old hydrography is more or less disturbed by warpings of the earth's crust, which, however, do not obscure the valleys, although rendering the features somewhat more complex. The amount of distortion has yet to be determined.

IV.—Woodwardian Laboratory Notes.

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1.—Specific Variation in *Sigillariæ.*

No better example could perhaps be quoted of fossil plants which have given rise to a number of species and even genera founded on imperfect and fragmentary specimens than the *Sigillariæ* and *Lepidodendra*.

Our knowledge of the internal structure of these plants has so far increased in recent years that we are now able to appreciate the differences between stems or branches of plants which have been preserved with their cortical tissues entire, and those which have been to a greater or less extent decorticated.

Genera like *Knorria, Aspidiaria, Bergeria,* and others are now generally recognized as imperfectly preserved Lepidodendoid stems.

We propose to confine ourselves in the present instance to the *Sigillariæ.* As a general rule, for purposes of classification and specific determination, we have to rely on certain external characters of the stems or branches. Seeing how the surface of a partially decorticated stem differs in appearance from that of a stem with its outermost cortical tissues preserved, one cannot be too careful in selecting well-preserved specimens before venturing to make any definite statements as to specific character. Mr. Kidston[1] lays special stress on this point. He remarks: "When determining the various species of the genera *Lepidodendron* and *Sigillaria,* unless the outer surface of the bark is well preserved and exhibits the form and arrangement of the leaf-scars, it is admitted that the plants do not show the characters by which a specific, or even in some cases a generic determination can be made."

The *Sigillariæ* may be divided into four sections or groups, *Rhytidolepis* (Sternberg), *Favularia* (Sternberg), *Clathraria* (Brongniart), and *Leiodermaria* (Goldenberg); or a more convenient classification is that adopted by M. Zeiller,[2] and others, where we have only three sections, *Rhytidolepis, Clathraria,* and *Leiodermaria.*

Such a classification as this, although convenient, is necessarily unsatisfactory, and one must expect from time to time evidence to be forthcoming which tends to break down the artificial barriers or fill up supposed gaps between the representatives of the several sections.

Some striking examples have recently been brought forward by Herr Weiss, of Berlin, and M. Zeiller, of Paris, of connecting links between two of these sections.

It may not be without interest to give a short resumé of the three papers in which proofs are given of the gradual passage from a type figured by Solms-Laubach[3] as representative of one section, *Leiodermaria,* to one quoted by him as an example of another section, *Clathraria.*

In the "Zeitschrift der Deutschen Geologischen Gesellschaft," for 1888, p. 565, there appeared a short notice by Weiss, "Ueber neue Funde von Sigillarien in der Wettiner Steinhohlengrube." In this paper he deals especially with specimens of *Sigillaria* recently found in the Coal-measures of the Wettin district, *Sigillaria spinulosa* (Germar), belonging to section *Leiodermaria,* and *S. Brardi* (Brongniart), one of the *Clathrariæ* (*Cancellatæ,* Weiss). To quote Weiss's words—"Of exceptional interest is a large series of specimens which, beginning with *S. spinulosa,* gradually passes, almost without a break, into *S. Brardi.* In this case there is no recognizable division between *Leiodermariæ* and *Cancellatæ,* indeed it is

[1] Ann. and Mag. Nat. Hist. vol. xvi. 5th series, p. 123.
[2] Flore fossile du bassin houiller de Valenciennes, p. 512.
[3] Einleitung in die Paläophytologie, p. 249.

difficult to separate the species of this series from one another." He goes on to describe Germar's[1] *S. spinulosa*, characterized by an even surface and peculiar small scars occurring below the leaf-scars, probably representing points of attachment of roots; these scars, which gave rise to the term *spinulosa*, are found to be by no means constant in their occurrence. Some specimens are mentioned by Weiss, from the Halle Collection, which agree in all points with *S. spinulosa*, except that the root (?) scars are absent; the surfaces of these specimens are marked with longitudinal and transverse wrinklings. Immediately below the leaf-scars the transverse wrinklings appear more prominent than the longitudinal, and this region becomes to some extent emphasized or distinct. In all the specimens these transverse and longitudinal wrinklings occur more or less pronounced; the subquadrate form of the leaf-scar is another fairly constant character. On examining the series of specimens Weiss noticed that the leaf-scars were farther apart in the forms with an even stem surface, and that the distances between them diminished as the leaf-cushions became more and more developed, or, in other words, as the *Clathraria* character became more marked. Four figures are given, showing a passage from a *Leiodermarian* form in which the wrinklings on the surface of the stem are very conspicuous, and in which there is an indication of undulating lines between the leaf-scars, through an intermediate form, called by Weiss *S. Wettensis*, to the typical *S. Brardi*. As the leaf-cushions become more and more completely formed, the surface wrinklings become less and less conspicuous. Clear evidence is given of an intimate connexion between the two sections *Leiodermaria* and *Clathraria*.

In the Neues Jahrbuch für Mineralogie, etc. (Jahrgang 1889, p. 376), Weiss brings forward further evidence of the absence of any definite line of demarcation between *Leiodermarian* and *Clathrarian* types. A piece of thick, somewhat flattened stem, is described from the collection in the Halle Museum, showing on one side the *Clathrarian* type *S. Brardi*, and on the other side the *Leiodermarian* type *S. spinulosa*. A second specimen is referred to from Halle which shows a passage from a form resembling *S. Defrancei* (Brongniart), one of the *Clathrariæ*, to a *Leiodermarian* form. The facts adduced by Weiss are considered by him to show that in certain cases the *Leiodermaria* form of surface represents a later, the *Clathraria* form an earlier state of the plant's growth. This does not, says Weiss, hold good probably in all cases; possibly many *Sigillariæ* have *Leiodermarian* characters during the whole of their life, and others retain *Clathrarian* characters. Some cases, however, occur where the two types are simply expressions of differences in age or development.

Weiss divides the *Sigillariæ* into two main groups:—

A. *Subsigillariæ.*		B. *Eusigillariæ.*	
1. *Leiodermariæ.*	2. *Cancellatæ.*	3. *Favulariæ.*	4. *Rhytidolepis.*

[1] Die Versteinerungen des Steinkohlengebirges von Wettin und Löbejün. taf. xxv.

It is known that *Favulariæ* and *Rhytidolepis* pass into *Cancellatæ* and *Favulariæ*; that *Leiodermariæ* pass into *Clathrariæ* has already been shown. One may quote here, as bearing on the remarks of Weiss, a sentence from Solms-Laubach,[1] "Whilst *Rhytidolepis, Clathraria*, and *Favularia* are connected with one another by intermediate forms, the same cannot be said of the *Leiodermariæ*, in which the leaf-cushions, as such, are entirely wanting, and on whose perfectly smooth cortical surface the leaf-scars are situated at a considerable distance from one another." In the "Bulletin de la Société géologique de France,"[2] M. Zeiller publishes some interesting notes, "Sur les Variations de formes du *Sigillaria Brardi*, Brongniart," in which he begins by referring to the attempt made by Boulay[3] to reduce the unnecessarily large number of species of *Sigillaria*. Zeiller[4] himself has pointed out certain differences which should be referred to differences in growth, and are not such as to justify the separation of distinct species.

A photograph is given by Zeiller of a specimen of *Sigillaria* showing perfectly clearly that *Leiodermarian* and *Clathrarian* types pass into one another. In the upper part of this specimen the leaf-scars are very prominent, broader than high, and separated by well-marked grooves, in fact we have here the characters of *S. Brardi.* Towards the lower end of the specimen the grooves gradually disappear and the leaf-scars get farther apart, the cushions become less and less distinct and the surface becomes even, having the characteristic wrinkling ornamentation. Still further towards the lower end the leaf-scars tend to come together again. The middle part of the specimen corresponds very closely, except in having no root (?) scars, with *S. spinulosa.* "*S. spinulosa* is then only a condition of *S. Brardi*, corresponding to a more rapid elongation of the stem or branches." By examining very carefully the *S. spinulosa* part of the specimen, a slight indication can be detected of the leaf-cushions, which become gradually more pronounced, until we have finally *S. Brardi.* In other parts the surface of the stem is perfectly even, and no traces of leaf-cushions can be seen. M. Zeiller points out that, in spite of these variations, there are certain features which remain constant; the form of the leaf-scars, the relative position of the cicatriculæ on the leaf-scars, and the mode of ornamentation of the bark. M. Zeiller[5] has previously given what he considers the most constant characters on which to rely in the determination of species. In the present paper reference is made by Zeiller to a specimen of *S. spinulosa* described by Renault showing leaf-scars on the fruit-bearing branches corresponding in shape and position to those of *S. Brardi.*

Attention is called to the fact that although such apparently different types as *S. spinulosa* and *S. Brardi* have been shown to be

[1] *loc. cit.* p. 251.
[2] 3e sér. t. 17 (1889), p. 603.
[3] Le terrain houiller du Nord de la France, p. 47.
[4] Flore foss. du bassin houiller de Valenciennes, p. 513.
[5] *Ibid.* p. 513.

simply different conditions of one and the same plant, yet there are certain distinctions and constant characters which must keep us on our guard against uniting as one species what are really distinct forms. One of the examples cited in illustration of this is *S. Moureti*, which suggests a very close relationship with *S. Brardi*; it is distinguished, however, from *S. Brardi* by the complete absence of an indentation on the upper edge of the leaf-scars, by the higher position which the cicatriculæ occupy on the leaf-scars, and by the round form of the lateral cicatriculæ placed somewhat above the central or vascular bundle cicatricula.

As further illustrating the variations in size of the leaf-cushions and leaf-scars on one and the same specimen I may add a few notes on three specimens which I had the opportunity of examining last year in the museums of Berlin and Breslau.

1. *Sigillaria* of *Rhytidolepis* type from the Coal-measures of Altenessen; in the Bergakademie Museum, Berlin. This specimen serves to show the differences in the size of the leaf-scars, the variation in breadth of the furrows and in the distances between the scars. Four ribs shown, three rows of leaf-scars. Breadth between ribs 1 & 2 = 3cm.; between ribs 2 & 3 = 2·3cm. Length of leaf-scar between ribs 1 & 2 = 9 mm.; breadth of ditto = 1·2 mm. The distance between the leaf-scars in the first furrow, *i.e.* between ribs 1 & 2, varies from 1·1 cm. to 1·3 cm. Length of leaf-scar between ribs 2 & 3 = 1 cm.; breadth of ditto = 8 mm. The leaf-scars in the third furrow, *i e.* between ribs 3 & 4, correspond closely with those in the second furrow. The specimen agrees closely with *S. principis* (Weiss) and *S. lævigata* (Brongniart).

2. *Sigillaria* from Coal-measures of Bochum; in the "Goeppert Collection," Breslau University Museum. Length of stem, 28 cm.: average breadth = 6 cm. Details not very clear. At the upper end the leaf-scars and cushions are of the *Rhytidolepis* type; the distance between these leaf-scars = 3 to 4 mm. Breadth of leaf-scar = 3·5 mm.; length = 3·5 mm.

Passing down the stem the leaf-scars rapidly get closer together, until they are almost contiguous, showing a passage from a *Rhytidolepis* to a *Favularia* type. Towards the lower end of the specimen are indications of vertical fruit-bearing scars, below this the leaf-scars become farther apart again. Zeiller[1] figures a specimen showing a somewhat similar case of variation in the distances between the leaf-scars (*S. Sauveuri*, Zeiller).

3. *Sigillaria*. Specimen in the "Goeppert Collection."

The leaf-scars of the upper part have a breadth of 4·5 mm., and a length of 2 mm.; on the lower part the leaf-scars have a breadth of 2·5 mm., and a length of 2 mm. The former agree closely with *S. microrhombea* (Weiss),[2] var. *nana*, the latter with *S. cancriformis* (Weiss), vars. *Paulina* and *S. acarifera*.

[1] *loc. cit.* pl. lxxxiv. fig. 1.

[2] For figures of Weiss's species, v. "Die Sigillarien der Preussischen Steinkohlengebiete," Abhand. zur Geolog. Special-Karte von Preussen und den Thüringischen Staaten, Band VII. Heft. 3, Taf. vii. and xiv.

2.—*Tylodendron*, Weiss, and *Voltzia heterophylla*, Brongn.

In 1869 Prof. Weiss instituted a new genus *Tylodendron*, which he defined as follows:[1]—"Plantae arboreae, amplis intervallis ramosae. Rami teretes, longi crassique, obtuse terminati, pulvinis rhombeis plus minusve elongatis et acuminatis spiraliter dispositis aequalibus vel repetito-abbreviatis tecti. Pulvinorum pars superior sulco acuto ab altissima pulvini parte oriente in crura bina parallela contigua longissima divisa. Corpus ligneus vasa porosa poris 1-, 2-, 3-seriatis confertis et radios medullares notatos exhibens; annuli lignosi inconspicui."

The general characteristics of the genus are considered to be those of a Conifer;[2] the only point in which a difference exists being the presence of a slit in each of the elongated areolæ: this slit Weiss regards as an indication of the former existence of a resin-canal, like those which occur in the leaves and stems of our recent Conifers. It is suggested as possible[3] that the present surface of the fossil, which is covered with rhombic areolæ, may represent the internal cast of a stem.

Dr. Potonié, of Berlin, contributed a paper to the "Jahrbuch der Königl. preuss. Geologischen Landesanstalt for 1887, p. 311,[4] in which he gave the results of a detailed examination of several specimens and sections of *Tylodendron*; he arrived at the conclusion that *Tylodendron* is not the wood, but the pith of a Conifer, probably that of an *Araucaria*. *Artisia* is referred to as a similar case of a pith-cast, whose true nature was first brought to light by an examination of sections showing internal structure. Pith-casts of *Stigmaria* occur which bear a close resemblance to *Tylodendron*. Potonié cites figures given by Williamson[5] as instances of such casts: fig. 65 of Williamson's monograph shows, for example, not only similar rhombic areolæ, but also the slits extending along half the length of each areola as *Tylodendron*. Weiss has figured his specimens of *Tylodendron* in an inverted position, he regarded the pointed end of the specimen in Tab. xix. and xx. as representing the tapering off of the stem towards the upper end: as a matter of fact, according to Dr. Potonié, the slit extends from the *lower* end of each rhombic areola, and marks the position of the foliar bundles, as that in *Stigmaria* shows the position of the rootlet bundles.

Dr. Potonié has examined a large number of recent coniferous stems, and finds that a cast of the medullary cavity of *Araucaria brasiliana* closely resembles small specimens of *Tylodendron*.[6] I

[1] "Fossilen Flora der jüngsten Steinkohlenformation und des Rothliegenden im Saar-Rhein-gebiete," p. 182.

[2] Parkinson figures a fragment of what appears to be *Tylodendron*; no locality is mentioned, see "Organic Remains of a Former World," vol. i. pl. iii. fig. 4.

[3] Fossilen Flora der jüngsten Steinkohlen, etc., p. 183.

[4] "Ueber die fossile Planzen-Gattung *Tylodendron*." Three plates accompany this paper, illustrating the external appearance and microscopic structure of *Tylodendron*.

[5] "A Monograph on the Morphology and Histology of Stigmaria Ficoides. (Palæontographical Society, 1887), pl. xiii. figs. 64 and 65.

[6] Potonié, *loc. cit.* Taf. xiii. a.

have had an opportunity of seeing the original specimens on which Weiss founded his genus, and also the casts taken by Potonié of medullary cavities of recent Conifers. I was at once struck with the practical identity of the two sets of specimens, and felt convinced of the correctness of Potonié's conclusions.

In looking through the collection of fossil plants in the Strassburg Geological Museum, I found a specimen of *Voltzia heterophylla* which seemed to me a most interesting example of a case, in which what looks like a cast of an entire stem covered with elongated leaf-bases, should in reality be considered as simply a cast of the medullary cavity.

Fig. 1. — Length of areola 1 = 8 mm. 2 = 9 mm. 3 = 1 cm.

The elongated areolæ, I consider, correspond to those of *Tylodendron*, and represent casts of the inner ends of the primary medullary rays. All that remains of the wood and cortical tissues is a small amount of carbonaceous matter on either side of the central cast. In this specimen of *Voltzia* the areolæ are more elongated than in *Tylodendron*; but in both cases we have the slit extending upwards from the lower end of the areolæ representing the position of the foliar bundles. The *Voltzia* cast shows no periodic swellings as in *Tylodendron*, nor any alteration in the length of the areolæ such as occurs in the neighbourhood of the swollen portions of the latter genus. Similar swellings and accompanying variations in the length of the areolæ occur in casts of medullary cavities of recent *Araucariæ* at points where verticils of branches are given off. The specimen referred to closely resembles those figured by Schimper [2] from the same locality—Soulx-les-Bains. The axis, which consists of an iron-stained core, projects above the surface of the rock; the elongated lozenge-shaped areas are not sufficiently well preserved in all parts to be accurately measured; but in Fig. 1, I have attempted to represent a few of them as correctly as possible. On each side of the iron-stained axis are traces of carbonaceous matter; some also occurs here and there on the axis itself. In the Palæontographica for 1886 [2] Dr. Blanckenhorn figures and describes some fragments of what he considers *Voltzia heterophylla*: these figures agree closely with the specimen here described. Blanckenhorn's specimens are described by him as branches from which the leaves have fallen, their surfaces being covered with long leaf-cushions separated from one another by furrows: each cushion has a groove extending from the lower end to the middle. The close resemblance of these

[1] Schimper et Mougeot, Plantes Fossiles du grès bigarré, pt. 1, tab. xiv. etc.

[2] "Die Fossile Flora des Buntsandsteins und des Muschelkalks der Umgegend von Commern" (Palæontographica, Band xxxii.), p. 135, taf. xxii. 18–20.

branches to *Tylodendron* is pointed out by Blanckenhorn, who agrees with Weiss that the slits in the so-called leaf-cushions represent resin canals.

That these specimens described by Blanckenhorn are really casts of medullary cavities of *Voltzia heterophylla* I have no doubt; what he took for leaf-cushions, and what Weiss regarded as such in the case of *Tylodendron*, are the casts of the internal ends of the medullary rays, and represent radial prolongations of the medullary tissue.

V.—The Physiography of the Lower Trias.

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

THE question of the physical conditions under which the Lower Triassic sandstones and pebble-beds were formed is certainly one which should interest all readers of the Geological Magazine, if only that it is strange that it should still be an open question whether so important a formation is of marine or fluviatile origin.

Perhaps a few words from one who takes a keen general interest in the subject, but who has no special theory to defend, may help to define the issues and to show how far the arguments adduced on each side influence a reader who had no previous bias. Far be it from me to pose as a judge or arbitrator. I only wish to write from the "intelligent public" point of view.

As Mr. Mellard Reade opened the present discussion, I take his arguments first, and three of them seem to be strong points:—

1. The universal sandiness of the Lower Trias. Considering that the deposit rests on and against Carboniferous Limestone, Millstone-grits, Coal-measures and Permian rocks, it is curious that pebbles derived from these rocks should be so rare in the Triassic conglomerates; where too has all the shaly material from the Carboniferous series gone to? These questions are greater difficulties on the fluviatile than on the marine hypothesis. Prof. Bonney does not attempt any actual explanation, but only cites analogous cases from the Alpine regions.

2. The existence of Lower Trias sandstone in the vale of Clwyd, a valley that drains from south to north, is admitted as a difficulty by Prof. Bonney.

3. The greater thickness of the pebble-beds in the midland counties and the diminution in the size of the pebbles toward the north. This is certainly a valid argument against the theory that the pebbles have been brought from the north, and so far as I am aware it has never been fully met by Prof. Bonney.

Let us now turn to the three points adduced by Prof. Bonney in the Geol. Mag. for February as adverse to Mr. Reade's view; and of which, by the way, only one is discussed in Mr. Reade's rejoinder.

1. The strength of the marine currents necessary to move large pebbles in water of any depth. This is partially met in Mr. Reade's reply, but the facts he quotes are not very convincing, and Mr. Hunt's letter in the same number challenges the accuracy of his inferences. The idea that the deep valley-like trench in the Irish

Sea has been excavated by the tidal scour is surely a complete assumption; by many it is regarded as an ancient submerged valley.

2. If the waters of the Lower Trias were marine, Prof. Bonney naturally asks in which direction they communicated with the open sea? The group thins out both northward and southward, and it is also doubtful whether there was any connection between the eastern and western basins at this period. The Bunter beds are thickest in North Cheshire, and if there was any communication with the open sea, Mr. Reade must be prepared to bring in the Atlantic either through St. George's Channel or the North Channel.

3. The question—Could such thick pebble-beds be accumulated on a sea floor?—is certainly one which requires an answer, and has not been answered by Mr. Reade.

To sum up, it seems to me that each advocate has one strong point which has not been met by his opponent, and that one or the other of these difficulties must be explained before either theory can be accepted as geological history.

If the pebbles were brought from Scotland in Triassic times, as Prof. Bonney believes, how did the largest pebbles get spread out into a conglomerate 90 feet thick at that end of the basin which would be farthest from the source of the river?

If on the other hand we are to entertain the introduction of a Triassic sea, Mr. Reade must not only indicate how its waters gained access to the midland counties, but how such thick beds of pebbles could be accumulated beneath this sea.

With regard to the nut that Prof. Bonney's hammer is expected to crack, I would like to ask why he feels so sure that the pebbles came from Scotland in Triassic rivers, and why they should not have been derived from some still older conglomerate, the remnants of which are now concealed from view. The existence of a breccia at the base of the Bunter conglomerates in Worcestershire is an interesting fact. Are the contents of the breccia all of local origin, or are there quartzites among them?

With respect to the accumulation of pebble-beds, I think Mr. Reade might have asked Prof. Bonney why he need assume that the water was deeper in the south than the north? Triassic levels were not the present levels, and though Prof. Bonney's theory demands a continuous southerly slope, that of Mr. Reade does not, and I fail to see why there must have been deep water over Central England in order to bring tidal waves over the north-western region.

Finally, is there any proof that the pebble-beds were laid down everywhere at the same time, and might not the Staffordshire beds have been originally beaches at the head of a bay, subsequently spread out and distributed by storm waves (not tidal waves) during a somewhat rapid subsidence of the area? Could not submarine pebble-beds of considerable thickness be formed in this way? I am only suggesting an answer to Prof. Bonney's question, and asking for its consideration. I am not adopting it as a theory, for I cannot yet see that there is a single item of positive evidence for the marine origin of the Lower Trias.

VI.—The Culm-measures at Bude, North Cornwall.

By Major-General C. A. McMahon, F.G.S.

My paper on the Culm-measures at Bude has elicited two communications, from Messrs W. Maynard Hutchings and Alfred Harker, on which I desire to offer a few comments.

I take this opportunity of saying that I am extremely glad to find that the conclusion at which I arrived regarding the impotence of pressure alone to produce metamorphism is in accord with the published views of my friend Mr. J. J. Harris Teall. "Pressure" alone, he states, in a footnote at p. 410 of his valuable work, British Petrography, "produces no effects on rocks—work must be done upon rocks before change takes place." This footnote escaped my memory at the time of writing my paper, or I should have called attention to it.

I now turn to Mr. W. M. Hutchings's letter. He points out that he collected two specimens of Bude rocks "a few inches apart," and after "a close study of very thin portions of slides under high powers," he found acicular crystals, and dark rods of rutile, "perfectly distinct from any bits of that mineral which may have come from older rocks."

I did not notice any rutile in my slices; but whilst I readily accept Mr. Hutchings's assurance that high powers applied to specially thin portions of his slides revealed the presence of rutile, I fail to see how this fact proves that metamorphism has been set up in the Bude rocks.

Mr. Teall has shown [1] that rutile needles occur abundantly in rocks so absolutely untainted with a suspicion of metamorphism as clays; moreover, Mr. Dick found rutile in the Hampstead Sands.[2] Unless Mr. Hutchings can adduce cogent evidence to prove that the rutile needles in his Bude specimens were formed after the Bude beds were laid down, I think the natural inference is that they were, like the needles of this mineral found by Mr. Teall in his clays, and the crystals in the Bagshot Sands of Hampstead Heath, floated to the spot with the rest of the fine material of which these beds are composed. Mr. Hutchings, it is true, alleges that his slides contain "secondary sericitic mica"; but he does not favour us with any evidence to prove either that the mica is sericite or that it is of secondary origin.

Rosenbusch says, "the optical behaviour" of sericite "is exactly the same as that of muscovite;"[3] and "it is probable that substances of different composition are included under sericite."[4] In J. D. Dana's Third Appendix, sericite is said to be "a massive muscovite, as shown by Laspeyres, who explains the varying results of earlier investigations by the greater or less impurity of the substance examined."

Mr. Hutchings also relies on the presence of crystals of tourmaline,

[1] Min. Mag. vol. vii. p. 201.
[2] Nature, vol. xxxvi. p. 91; and Brit. Petrography, pl. 44, fig. 4.
[3] Microscopical Physiography, by Iddings, p. 265. [4] *Ibid.*

which he states are "quite distinct from the clastic grains of that mineral." I noted in my paper that the specimens of the Bude rocks examined by me contain fragments of schorl (tourmaline) and needles imbedded in quartz grains that may be referred to this mineral. Mr. Hutchings does not explain in what respect the crystals on which he relies are "quite distinct" from the "clastic grains," or whether these crystals are imbedded in or attached to quartz grains or not. If he means that they present idiomorphic shapes, and are not obviously fragments, that fact does not prove that they were formed after the beds that contain them were deposited. I have in my collection minerals showing very perfect crystallographic shapes collected from river sands. Mr. Dick showed the presence, not only of "sharply-edged prisms" of rutile, but of "perfect crystals" of tourmaline in the Bagshot beds at Hampstead.[1] I was at pains to show in my paper that the material of which the Bude Culm-measures is composed did not travel far; that the current which deposited it was very sluggish; and that the granules of which the Culm-measures are built up are not water-worn.

With reference to Mr. Hutchings' remarks on "Hallock's experiments and conclusions, it seems sufficient to observe that so good an authority as the Rev. O. Fisher thought Mr. Hallock's experiments and conclusions sufficiently valuable to quote in the second edition of his "Physics of the Earth's Crust."[2]

I turn now to Mr. Harker's letter. I think the readers of the Geological Magazine are to be congratulated on this interesting and able contribution to the discussion of dynamic metamorphism. Nothing could be more lucid than Mr. Harker's short exposition of the way strains in rock-masses resolve themselves into voluminal compression and shearing. I see no room to differ from Mr. Harker's statement of the principles that govern strains; and in the following remarks my object is to make my own position clear, rather than to criticize his letter.

In my paper on the Bude rocks I expressly restricted my conclusions to the results of "pressure alone." Mr. Harker's remarks, on the other hand, refer to the effects of "(i) uniform voluminal compression, and (ii) certain shears;" that is to say, to the two principal mechanical sources of heat.

To quote from the Rev. O. Fisher's Physics of the Earth's Crust (second edition, p. 2): "Pressure by itself cannot develope heat. That takes place only when some kind of motion, which however slow may be termed "visible," is arrested and transformed into that invisible motion of the ultimate molecules of a body which constitutes heat." On the other hand, the fact that voluminal compression and friction (shearing) are mechanical sources of heat belongs to the elements of physics.

If "pressure alone" cannot develope that form of molecular energy known as heat, it cannot develope those other forms of energy into which heat is convertible.

[1] Nature, vol. xxxvi. p. 91, and plate 44, fig. 3, British Petrography.
[2] Page 172, footnote.

Where there is shearing or voluminal compression, heat is generated, and molecular activity is increased. But the "energy set free" may be small in amount, and may be lost by conduction; and thus, to quote Mr. Harker's words, it is "easy to imagine conditions under which any amount of contortion may be produced without any metamorphism of the rocks so affected."

But there are some geologists who go beyond Mr. Harker, and contend that pressure produces metamorphism even in cases where the rock-masses do not yield to the pressure exerted on them; and where, consequently, there is neither shearing, voluminal compression, or "movements in the rock-masses."

Mr. Harker is under a misapprehension in supposing that I call "in question the researches of M. Spring and others on the physical and chemical changes produced under the action of high pressures." I spoke of M. Spring's experiments as "instructive and valuable." What I call in question is the way Spring's experiments are sometimes applied by others. The net results of M. Spring's experiments are well summarized by Prof. Judd in one of his papers as follows: "The researches of Spring, van 't Hoff, Reicher, and others, have shown the effects of pressure in bringing the molecules of solid bodies sufficiently close to one another for chemical affinity to operate between them." But it is obvious that chemical affinity can only operate when the substances brought into contact with each other are substances which have a chemical affinity for each other. I fail to see that M. Spring's experiments throw any light on what I consider the most important class of metamorphic changes that take place in a rock; namely, *metachemic* changes. When minerals during the progress of metamorphism have simply undergone paramorphic changes, there is little difficulty in accepting the view that these changes may have been brought about by pressure; but, when we have *metachemic* changes, that is to say, when a mineral of one chemical composition is converted into a mineral of a different composition, it is clear that pressure alone cannot account for the change set up. We need in order to explain these changes to call in the aid of some agent, such as water, to carry to the mineral in progress of alteration the chemical elements required which it does not itself contain, and to remove the chemical elements which it has to get rid of in whole or in part. The chemical elements required for the new mineral may exist in other minerals in some other part of the rock, but they need to be extracted from those minerals by one set of chemical reactions, and conveyed to the spot where they are made over to the mineral in progress of metamorphic change by another set of chemical reactions. For these operations we require water or some other agent. This circulating fluid then—water or other—is the active agent in promoting these changes, and all that compression, or shearing, can do is to provide the heat, or other form of energy, necessary to start or facilitate the requisite chemical reactions.

The agency of water, or some other circulating medium, is, as I have said above, necessary to account for metachemic changes; heat, no doubt, is also needed to aid these changes. Compression is a mechanical source of heat; but is the supply from this source, I would ask, as important as that due to plutonic causes? Mr. Harker admits that "under a comparatively small cover of rocks much of the energy" set free by compression "must be lost by conduction." But would not much of it be also lost in the case of deep-seated rocks? Rocks are bad conductors of heat, but the compression of deep-seated rocks must take place slowly; and as the amount of heat generated by compression would only be proportional to the reduction of volume, would not much of the heat be lost by conduction? Mr. Harker makes his voluminal compression depend upon two factors, namely, lateral and vertical pressure, the latter being dependent on the thickness of the cover. When the cover is thin, the energy set free by the lateral pressure may be lost, he explains, by conduction. But a thick cover is not put on suddenly. The deposition of sediment is a slow operation; and even when lateral pressure is applied after a thick cover has been formed, it would be applied gradually. In the case of rock-masses under the conditions supposed by Mr. Harker, namely, those so deeply buried that the lateral pressure would be balanced by the weight of the cover, I cannot conceive of a sudden generation of heat arising from a sudden arrest of motion of the nature of percussion. The heat due to a mechanical cause must be generated by gradual compression; and where the generation of heat is gradual, the loss of energy by conduction becomes an important element that must not be left out of our calculations.

As a source of energy it seems to me that plutonic heat supplies all we require. The Rev. O. Fisher, in his work already referred to, writes: "We have pointed out that, having regard to such depths as artificial excavations reach, the law of increase is on the whole an equable one, amounting on an average to about 1° Fahr. for every 51 feet of descent, if it be not even slightly more rapid."[1] The temperature that this rate of increase would give us, at the depths to which we may suppose that the rocks with which we are concerned have been buried, seems sufficient for the work of metamorphism without our indenting on dynamic agency for our supply of heat. How, moreover, are we to discriminate between plutonic heat and dynamic heat, and say that this, or that, bit of metamorphic work was done by the energy supplied from a mechanical source alone?

Mr. Hutchings, in his reference to M. Spring's experiments, alludes to the "intermixture of minute particles of minerals in the fine silt of which these Bude rocks and similar strata are largely composed," and adds, "all the crushing and grinding has been done in the gentlest and quietest way, and the resulting material has but to lie and await the pressure." But the point I desired to make in my paper was that though the material has been finely triturated by Nature's pestle and mortar and judiciously mixed together in Nature's laboratory, and although this mixture has sustained enormous

[1] *l.c.* p. 343.

pressure, no results worth speaking of have followed; and the Bude beds, M. Spring's experiments notwithstanding, are still in an "awaiting" attitude. I think these unfortunate rocks have some ground of complaint. They possess, as I have shown, the chemical composition of granite, but though they have certainly suffered many things at the hands of dynamic physicians, they have not been converted into granite; and indeed have not as yet made even a Sabbath day's journey towards that happy goal!

REVIEWS.

I.—The Geology of the Isle of Wight. By the late Henry W. Bristow, F.R.S., etc. Second Edition, revised and enlarged, by Clement Reid, F.L.S., F.G.S., and Aubrey Strahan, M.A., F.G.S. Geological Survey Memoir. 8vo. London, 1889, pp. 349. With Geological Map, Plates and other Illustrations. Price 8*s*. 6*d*.

The geology of the Isle of Wight has up to the present time been illustrated and described in two official memoirs, not to mention the one-inch Geological Survey Map, and a series of longitudinal and vertical sections. The Memoir on the Tertiary Fluvio-marine Formation, by Edward Forbes, was published posthumously under the editorship of R. A. C. Godwin-Austen, in 1856; the general Memoir on the Geology of the island, by Bristow, was published in 1862, and has long been out of print. For some years Mr. Bristow had been gathering materials for a revised edition of his work, but a re-survey of the island, on the Six-inch scale, made in 1886–87 by Messrs. Reid and Strahan, has enabled them to make so many and important changes in the Memoir, that the work may well be described as a new one.

On glancing at the tables of strata given in the two works, it will be noted that nearly double the number of subdivisions shown on the old map have been marked on the new edition. This is partly due to the mapping of the Recent and Pleistocene Beds. Mr. Strahan, however, has been able to map out the several divisions of the Lower Greensand, Upper Greensand, and Chalk, which were not before distinguished on the map. He points out that the Wealden rocks are separated from the Lower Greensand by a sharply-defined lithological demarcation, accompanied by a palæontological break, and by some erosion. When the name "Punfield Beds" was introduced by Prof. Judd, the true base of the Lower Greensand had not been discovered in the Dorsetshire locality, hence part of the "Punfield Beds" at Punfield was made up of Lower Greensand, while the whole of the group in the Isle of Wight was referable to the Wealden Beds. This inconsistency was shown originally by Mr. C. J. A. Meyer. His observations have been fully confirmed by Mr. Strahan, who gives further particulars of the beds exposed on the Dorsetshire coast, as well as in the Isle of Wight.

The Lower Greensand is now divided as follows :—

Carstone Sand-rock Series	= Folkestone Beds.
Ferruginous Sands Atherfield Clay.	= Sandgate and Hythe Beds.

It is remarked that the Carstone passes up into the Gault, and that the Sand-rock Series passes down into the Ferruginous Sands; while between the Carstone and Sand-rock Series the boundary is somewhat sharply defined, with an appearance even of slight erosion at times, though there is no evidence of an actual unconformity. Considerable interest, however, attaches to this subject, for in other places (as pointed out by Mr. Strahan) the Carstone passes up into the Red Chalk, which partly represents the Gault; while in the Kentish area the upper part of the Folkestone Beds (the zone of *Ammonites mammillaris*) is by some authorities placed rather with the Gault than with the Lower Greensand. Hence it seems probable that the base of the Upper Cretaceous series may ultimately have to be taken to include the Carstone.

With regard to the Gault, while the main mass belongs to the upper division, it would seem that to some extent the lower division is represented palæontologically; some few species have been added to the general list of fossils, but there is room for further detailed work on the palæontology of this formation. The Upper Greensand has been separated into the Malm Rock and Chert Beds; and the Chalk has been subdivided into Chloritic Marl, Middle and Lower Chalk with Melbourn Rock, Chalk Rock, and Chalk-with-flints. The cliff-sections showing the Upper and Lower Cretaceous rocks have been remeasured, and important additions have been made to the illustrative sections.

In the classification of the Tertiary strata, we find some changes introduced. The name Headon Hill Sands is (provisionally) employed in preference to Upper Bagshot Sands, because they probably belong to a higher zone than the Upper Bagshot Series of the London Basin. They are overlain by the Headon Beds, which form the base of the Oligocene division (or Fluvio-marine Formation of Forbes). For the uppermost portion of this division the name Hamstead Beds is now adopted instead of the "Hempstead Series" of Forbes, as the former is the mode of spelling used in the Isle of Wight. Mr. Reid has proved that these beds extend over a much larger area in the island, and have a greater thickness, than was formerly supposed. Concerning controversial points, it is remarked that "Forbes's correlation is followed in this Memoir, for though there are some minor points on which Prof. Judd's criticisms are no doubt just, yet with regard to the main difference the recent re-examination of the island and mapping of the beds on the scale of 6 inches to the mile have not supported Prof. Judd's contention, but rather shown that Forbes's correlation must still be accepted."

Many additions and corrections have been made by Mr. Reid to the accounts of the Tertiary strata and to the sections illustrating them; and an account of the Flora of the Pipe-clay in the Lower

Bagshot Beds of Alum Bay has been contributed by Mr. J. Starkie Gardner, who thus revises the work done previously by Dr. P. De la Harpe and Mr. J. W. Salter.

The superficial deposits are now described much more fully than previously. They include the Angular Flint Gravel of the Chalk Downs, which is in part a sort of "Clay-with-flints," without much clay, representing the insoluble residue of a great thickness of Upper Chalk. It contains also flint-pebbles, grains of quartz, and other rocks. There are also Plateau Gravels, probably of Glacial age; and Valley Gravels and Brick-earth of later Pleistocene age, that yield remains of Mammoth, Rhinoceros, and Palæolithic Implements. Recent deposits of Alluvium and Peat, Blown Sand, etc., are duly described.

An interesting chapter on Faults and Disturbances gives us an account of the remarkable folds in the strata, and of the occurrence of thrust-planes or slide-faults. The double anticline of the Isle of Wight is one of a series that occurs in the south and south-east of England, traversing the country in an easterly and westerly direction, and having a steeper inclination on the north side. It is remarkable that the same features characterize the folds in the older rocks of the Mendip Hills.

Messrs. Reid and Strahan point out that in the Isle of Wight the sudden downward plunge of the beds on the north side of the anticline seems to be the first stage in the formation of a thrust-plane or slide-fault, and on the neighbouring coast of Dorsetshire, an actual thrust-plane is seen in the Chalk, and this was described and figured by Thomas Webster in 1811 (in Englefield's Isle of Wight). As pointed out, the date of the great movements may be assigned approximately to the Miocene period.

An interesting, but very brief chapter on Physical Geography, deals with the origin of the leading physical features. It is shown that the lines of drainage were determined by the anticlines and synclines which form so marked a feature in the geology; and that while these lines have been maintained, the form of surface due to the original movements has been lost.

The subject of the separation of the island from the mainland is very briefly alluded to, and we hope in a third edition, it may receive due attention, when some reference may also be made to the remarks of the Rev. W. Fox and of Dr. John Evans on this interesting topic.

The final chapter deals with the Economic Products; and the Appendices include Tables of Fossils, Accounts of Wells Sections, and Bibliography.

II.—The Bala Volcanic Series of Caernarvonshire and Associated Rocks. Being the Sedgwick Prize Essay for 1888. By Alfred Harker, M.A., F.G.S. (Cambridge University Press, 1889.)

THE examiners for the Sedgwick Prize at Cambridge have done good service to petrography in opening up the igneous rocks of Caernarvonshire to investigation. Mr. Harker, the winner of the prize, has published the substance of his essay, illustrated by three small scale and three large scale maps.

The introduction divides the county into three areas; two lie east and west respectively of the Llyn Padarn ridge, while the other includes the Lleyn peninsula. A bibliography is appended.

There are five main outflows of rhyolitic lavas, whose limits are traced on a map which enables the author to suggest that the intrusive masses near Y Foel Fras and that of Mynydd Mawr are their centres of eruption. A few, but too few, analyses of the rhyolites are given, and these indicate the presence of the following minerals, in order of abundance—quartz, orthoclase, albite, pinite, and magnetite. The usual structures are crypto-crystalline and micro-crystalline, but a remarkable type from the lowest lavas is of the nature of an ophitic structure, in which quartz encloses felspars; something similar to this was observed by Teall[1] in the rock of Penmaenmawr. Fragmental and quasi-fragmental rocks seem to be much less common than is usually supposed. In a chapter on the nodular felsites Mr. Harker comes to the general conclusion that the structures arise from solid spherulites, in which either the centre has been replaced by amorphous silica or the shrinkage due to molecular re-arrangement has formed concentric cracks along which alteration has proceeded.

The acid irruptive masses are usually augite granophyres, such as those of Y Foel Fras, and granite porphyries generally augitic, like the intrusions of the Rivals, and occur as cylindrical necks or laccolites. Hornblende is often absent from these rocks; the well-known dark patches are of concretionary origin.

In the description of the intermediate rocks that from Penmaenmawr receives still another name, "bronzite bearing quartz dolerite," and the augite and bronzite andesites of the Lleyn are investigated; most of the latter appear to be intrusive, though conclusive evidence is not given, while there are certainly some andesites associated with agglomerates and ashes.

The adoption of the word "sill" for the intrusive diabase sheets is devoutly to be wished for; such sills are known to be very commonly intruded between the beds of the other volcanic rocks, and, with the doubtful eruption of Porth-Dinlleyn, the diabases are never in the form of lava-flows. The absence of dykes is significant, and the few exceptions appear to be later intrusions injected into the post-Carboniferous joint system. The sills have probably been intruded into cavities or planes of weakness formed during the folding of the strata. Olivine is absent even from the post-Carboniferous intrusive rocks.

After a chapter devoted to the altered gabbros, picrites and hornblende diabases of the Lleyn, the author gives a general review of vulcanicity in Caernarvonshire. A map elucidates the distribution of the cleavage-planes, and makes it quite clear by the increase of contortion and the perfection of cleavage that the pre-Cambrian mass of felsite near Llyn Padarn had a large share

[1] Teall, British Petrography, p. 273.

in resisting the south-easterly thrust to which these structures are due, and that it has even operated in the formation of the phyllites of the "Llanberis slate zone," while it has sheltered the region to the north-west from cleavage and intrusion. The western district, being less affected and not possessing a resisting mass, has lagged behind the eastern, so that faulting and dynamic changes in the diabases have taken place about the junction region of Tremadoc. The foci of the main eruptions bear a relation to this thrust, and are found along a line to the south-east of, and parallel to, the Llyn Padarn ridge, indicating that the thrusting had begun before the vulcanicity.

The eruptive material, if of intermediate character to begin with, seems to have segregated before eruption occurred, so that the lavas are of acid character; the diabases on the other hand, owing to their density, were intruded as sills at lower levels, possibly in part during the main vulcanicity, but also and chiefly after the surface flows ceased; still later and lower are found the ultrabasic intrusions.

In this work we have a very large amount of observation and inference which will form a most useful groundwork when the district is studied minutely and mapped in detail, and then only can its deeper and more complicated problems be unravelled.—W. W. W.

III.—Memoirs by Robert Kidston, F.R.S.E., F.G.S.

1. On the Fossil Plants in the Ravenhead Collection in the Free Library and Museum, Liverpool. Trans. Royal Soc. Edinburgh, 1889, vol. xxxv. pp. 391–417, pls. i. ii.
2. On some Fossil Plants from Teilia Quarry, Gwaenysgor, near Prestatyn, Flintshire. Trans. Royal Soc. Edinburgh, 1889, vol. xxxv. pp. 419–428, pls. i. ii.
3. Additional Notes on some British Carboniferous Lycopods. Ann. Mag. Nat. Hist. 1889, pp. 60–67, pl. iv.

These Memoirs form valuable additions to the literature of our British Palæozoic Flora. The report on the "Ravenhead Collection" is prefaced by a geological sketch of the district from the pen of Mr. G. H. Morton, author of the "Geology of the Country around Liverpool," the plants described having been collected in the Middle Coal-measures at Ravenhead, near St. Helen's, South Lancashire. The species referred to belong to the groups of the *Calamariæ*, *Sphenophylleæ*, *Filicaceæ*, *Lycopodiaceæ*, etc., *Sphenopteris Marratii* being described as a new form, whilst Stur's genus *Sphyropteris* (a Sphenopteroid fern) appears to be recorded for the first time from British rocks. The occurrence of *Zeilleria delicatula* is also mentioned. Unfortunately this genus established by the author in 1884 must, in accordance with the laws of priority, be dispensed with, that name having been applied by Prof. E. Bayle in 1878 to a genus of Brachiopods.

The Teilia Quarry plants are from the Carboniferous Limestone, and an interesting fact connected with them is their association with marine shells. Several of these plants were collected by Mr. E. B. Luxmoore, who generously gave his best examples to the Geological Department of the British Museum, the chief of which are here described and figured. They mostly belong to the order *Filicaceæ*, one being described as a new species, viz. *Sphenopteris Teiliana*. The elegant form of *Adiantides antiquus*, Ett., is recorded as a rare species from Britain. The geological notes to this paper are taken from the works of Mr. G. H. Morton.

The third contribution is an enlargement of the author's views as set forth in a previous paper "On the Relationship of *Ulodendron*, L. & H., to *Lepidodendron*, Sternb., *Bothrodendron*, L. & H., *Sigillaria*, Brong., and *Rhytidodendron*, Boulay," Ann. Mag. Nat. Hist. 1885.

Descriptions and figures are given of *Sigillaria discophora*, König. sp., *Bothrodendron Wükianum*, n. sp., and *B. minutifolium*, Boulay, sp. . A large amount of literature is quoted throughout the papers, but the absence of dates to the majority of the references is strongly noticeable. Unless accuracy is attained in this section of Palæontological work, synonymy will be difficult to prove or understand. The plates are very valuable, the figures having been drawn with careful detail and precision by the author himself. R.B.N.

IV.—A Catalogue of British Fossil Vertebrata. By Arthur Smith Woodward, F.G.S., and Charles Davies Sherborn, F.G.S. 8vo. pp. xxxv. 396. (London, Dulau & Co., 1890.)

NEARLY six-and-thirty years have elapsed since the late Prof. John Morris published the second edition of his well-known and still-useful *Catalogue of British Fossils*; being the latest in which all known species of British fossil Vertebrates are recorded; and necessarily its information falls short of the requirements of to-day; much having been achieved in the meantime in discovery, description and illustration of new forms, and also in revision and re-description of many of the earlier described species.

We therefore welcome the present volume as supplying a long-felt want. And the authors are to be congratulated on its inception, careful preparation, and its issue as a distinct publication. Its usefulness and merits will be fully recognized by all workers in this division of palæontological science. In respect to fulness of reference to the bibliography, number of localities cited, the amplitude of the synonymy and other information relating to the group, the Catalogue is the most comprehensive hitherto produced. The labour of research and compilation has been great, and pursued with persevering assiduity; in many cases the earliest notices of discovery of vertebrate remains, prior to that of specific description, have been traced and quoted. The nature of the specimens that form the types of species are stated; and when ascertainable, their present location, whether in private or public collections. References to the literature are not restricted to the publications in which the respective species were first described, but numerous original works and memoirs by specialists and other writers of acknowledged authority are also quoted.

As regards the nomenclature, with a few exceptions, the emendations of recent authors are generally adopted. Consequently there are many changes, both of the earlier and of later names; and some of these innovations certainly smack a little of the pedantic. A long-established and universally-adopted name is not readily supplanted by one of obscure origin, in obedience to some arbitrary rule of priority, either in the labelling of collections or insertion in text-books. In support of this contention, we note the substitution of *Microtus* for the long-known and familiar genus *Arvicola*: the first name having, it is said, a few months' priority of publication in a comparatively unknown work. The latter name, however, has been recognized by all British and European naturalists dating from the commencement of the century to the present time; and is found in all works on natural history, and palæontological text-books, where its species are referred to. There is nothing to be gained, scientifically or otherwise, by disturbing a name so long and generally accepted by the best writers on the Mammalia. However, these innovations cause no inconvenience, for the discarded names are readily found by cross-references placed in their due alphabetical sequence in the text. The synonymy is copious, and far exceeds in number the names accepted as valid; and much pains have been taken to trace every appellation a species has borne.

The stratigraphical position, and all well-authenticated localities whence derived, are given with each species. To some of the Pleistocene mammals the number appended is overwhelming; for instance, nearly two hundred places in Great Britain and Ireland are cited where remains of *Elephas primigenius* have been found.

It is no exaggeration to assert that, as regards its special subject, no such aid to lighten the labour of research for authorities and other particulars relating to it has ever been prepared for the benefit of vertebrate palæontology, and the book should find a place in every good reference library.

The Catalogue has also the merit of being the first compilation exclusively devoted to one natural division of our extinct fauna published in distinct form; and initiates a departure from the older method of inclusion in one work of all the various classes; and the same plan might be adopted with equal advantage for other palæontological groups.

It is matter of interest to note how much has been accomplished in advancing our knowledge of the British Fossil Vertebrata since 1854, the date of Morris's Catalogue; and the present work will, approximately, enable us to do this. Morris enumerates 350 genera of all classes of vertebrates, comprising 960 named species, and 35 unnamed as being then known. He gives few synonyms, and the localities cited seldom exceed one to a species; the whole occupying 48 pages of the Catalogue. But in the mean time more than 200 of these species have been merged in others, and have disappeared from our lists, the names only being found in the long roll of synonyms. These, therefore, have to be deducted from the total of the species then considered valid, thus reducing the number, as now accepted, to 760.*

* Species referred to *Ichnites* are not included in the above numbers.

In the work before us 662 genera are enumerated, containing 1534 species recognized as well founded, and 54 not specifically determined. The figures quoted show that about 800 new forms have been added to our extinct Vertebrate fauna since 1854; a fairly large number, having regard to the comparatively small area of the British Isles. But these new species only represent a portion of the large number actually described in the interval; for many, as a result of subsequent examination, or the acquisition of new evidence either by their authors or other palæontologists, have been incorporated with species previously established. The voluminous and valuable descriptive literature relating to them is distributed in many works specially devoted to the subject; Transactions and Journals of numerous scientific societies—metropolitan and provincial—and publications devoted to science, that it is difficult without the assistance of a system of comprehensive reference, such as the writers of this Catalogue have produced, to realize how extensive it is.

To have rendered their work absolutely complete as one of ready reference, the authors should have inserted a list of Families with the genera appertaining to each. A list of this description would be of immense service to many curators of provincial museums, and also to others having a general knowledge of one or more of its classes. So many revisions of the earlier—and also of some of the later—families and genera have been made by specialists, that without a library containing all recent memoirs relating to the subject at hand, it becomes difficult to ascertain their systematic position.

It is with reluctance we direct attention to this omission—probably an oversight—but it can be easily rectified in a future edition; and will add still further value to this already most valuable work.

REPORTS AND PROCEEDINGS.

Geological Society of London.

March 26, 1890.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On a new Species of *Cyphaspis* from the Carboniferous Rocks of Yorkshire." By Miss Coignou, Cambridge. Communicated by Professor T. McK. Hughes, M.A., F.R.S., F.G.S.

The author describes a fairly perfect head of a Trilobite found in the Pendleside limestone of Butterhaw, near Cracoe, which appears to belong to the genus *Cyphaspis*, though it differs from the typical species of that genus in possessing two pairs of glabellar lobes. The name *Cyphaspis* is proposed for this form.

2. "On Composite Spherulites in Obsidian from Hot Springs, near Little Lake, California." By Frank Rutley, Esq., F.G.S., Lecturer on Mineralogy in the Royal School of Mines.

The spherulites which form the subject of the present communication have been previously noticed, and it was then suggested that a smaller spherulitic structure was set up in the large spherules after their formation. In the present paper evidence was adduced in favour of a different mode of origin. It was argued that the small spherulitic bodies (primitive spherulites) were developed in the obsidian before it assumed a condition of rigidity, and that they floated towards certain points in the still viscid lava, and segregated in more or less spherical groups, though there is no evidence to show what determined their movements; furthermore, that from a point or points situated at or near the centre of each group, crystallization was set up, giving rise to a radiating fibrous structure, which gradually developed zone after zone of divergent fibres until the entire mass of primitive spherulites was permeated by this secondary structure—a structure engendering a molecular rearrangement of the mass, such as would obliterate any trace of structure which the primitive spherulites might have originally possessed.

In a supplementary note the views of Mr. J. P. Iddings with reference to the spherulites in question were given. Mr. Iddings considers that the structures here described as primary are of secondary origin. The author stated in detail his reasons for adhering to the conclusions given in this paper.

3. "A Monograph of the Bryozoa (Polyzoa) of the Hunstanton Red Chalk." By George Robert Vine, Esq. Communicated by Prof. P. Martin Duncan, F.R.S., F.G.S.

The fossils examined occurred on tests of Echinoderms and on the shells of *Terebratula biplicata*, *T. capillata*, Oysters, *Inocerami*, *Nautili*, and Ammonites. The best of the forms of *Diastopora* and *Proboscina* are found on *Inocerami* and Ammonites, but the most abundant individuals are *Stomatoporæ*, chiefly on *Terebratula biplicata*. Species of *Entalophora*, *Idmonea*, and "*Ceriopora*" are very rare or badly preserved, and Chilostomatous forms are also very rare.

In the present monograph the author felt obliged to limit or re-define the generic terms employed, and proceeded to describe in detail the forms which he has examined from the Hunstanton Red Chalk and other Cretaceous deposits, including the following new forms:—*Proboscina irregularis*, *P. uberta*, *P. gracilis* ?, var. *Reussi*, *P. claviformis*, *P. hunstantonensis*, and var. *ampliata*, *P. Jessoni*, *P. gigantopora*, *P. dilatata*, var. *cantabrigiensis*, *Diastopora hunstantonensis*, *D. fœcunda*, *D. Jessoni*, and *Membranipora gaultina*.

4. Evidence furnished by the Quaternary Glacial Epoch Morainic Deposits of Pennsylvania, U.S.A., for a similar mode of formation of the Permian Breccias of Leicestershire and South Derbyshire." By William S. Gresley, Esq., F.G.S.

The author noted that nodules of ironstone occurring in the Pennsylvanian glacial deposits of Quaternary age are scratched in precisely the same manner as those which he has described from the Permian deposits of Leicestershire and Derbyshire, and concluded that one and the same agency, viz. ice, has been instrumental in producing the observed results in both cases.

CORRESPONDENCE.

ON THE SUPPOSED PECTORAL LIMB IN *COCCOSTEUS DECIPIENS.*

Sir,—Permit me a few words in reply to Prof. v. Koenen's most courteous remonstrance concerning the supposed pectoral limb in *Coccosteus.*

Although I did indeed suggest that Prof. v. Koenen may have mistaken the outer margin of the interlateral plate in his *C. Bickensis* for a pectoral spine, I did so without dogmatism; and when I have the opportunity of examining the German specimens, I shall do so with a mind perfectly open to conviction.

But I stand firm as regards the position which I have taken up as regards the absence of any such "Ruderorgan" in *Coccosteus decipiens*, the type of the genus; and I do not think that the argument upon which Prof. v. Koenen bases his expectations of its ultimate discovery in this species, carries any weight whatever. When we take into account the position in the head of the sclerotic ring, its delicacy, and the manner in which the Scotch specimens are crushed, it is by no means astonishing that this structure should be so rarely observable in *Coccosteus decipiens.* Far otherwise would be the case with a pectoral limb, were such a thing present,—for it is simply incredible that a *long stout prominent external* appendage, like the "Ruderorgan" in Prof. v. Koenen's restored figure, should have escaped preservation in the hundreds and hundreds of specimens of Scotch *Coccosteus*, which are to be found in the museums of this country, many of which are absolutely entire from the tip of the snout to the point of the tail.

I cannot therefore share Prof. v. Koenen's expectations as to the future discovery of a pectoral limb in *Coccosteus decipiens*, and consequently must still maintain that if such a limb is really present in *C. Bickensis*, v. Koenen, that species must be removed to a new genus.

7th April, 1890. R. H. Traquair.

MR. MELLARD READE ON THE PHYSIOGRAPHY OF THE LOWER TRIAS.

Sir,—So kindly is the tone of Mr. Mellard Reade's reply to my criticisms on his explanation of the Physiography of the Lower Trias that it is not without regret that I am compelled to observe that in my opinion he has failed to meet them. His reply, in short, as it seems to me, errs in excess and in defect. In excess, for these reasons:

(1) I do not "misconceive the facts in speaking of the Bunter generally as a 'conglomerate.'" Mr. Mellard Reade has misunderstood my words by isolating my last paper from all that I have previously written. I have touched upon the anomaly of the Lancashire Bunter (of what I know something) twice at least (Geol. Mag. Dec. II. Vol. X. p. 204: Address to Sect. C, British Association, Birmingham, 1886). I did not again mention it, because I had nothing to add to my previous remarks. In reading the proof the

idea of inserting a protecting clause did indeed occur to my mind, but I abstained from so doing, because I supposed that I should be credited with the possession of what is common knowledge. Readers get wearied if, in writing geological papers, we imitate the style of legal documents. I dwelt upon the thickness of the Staffordshire pebble beds (which I understated rather than overstated), because the strength of a chain is the strength of its weakest link, and I cannot explain, for reasons already given, these conglomerates, as they occur over a considerable area of the Midlands, by Mr. Mellard Reade's hypothesis. The comparative absence of pebbles in the northern region is undoubtedly an anomaly for which we have not yet found the explanation (I could offer one, but, as it would be an hypothesis, I abstain on the present occasion, lest I should trespass too much on the Editor's tolerance). But on the hypothesis of a southern derivation, the much greater thickness which the Bunter group as a whole attains in the district about the Mersey compared with that in Staffordshire (more than double) is also an anomaly. To this I believe we might add—though here, as my personal observations are not very numerous, I must speak with caution—the greater abundance of felspar fragments in the sandstones of the Lancashire-Cheshire Bunter. So in this matter, as it appears to me, our difficulties are mutually destructive, like Kilkenny cats, and they may leave us much as they found us.

But I cannot understand how the nature of the sand in the Bunter helps Mr. Mellard Reade. "An inspection of the geological map of Scotland shows such a diversity of rock structure, and there exist such lithological differences in the various areas that would have drained into these two hypothetical rivers, as to seem irreconcilable with the required travel of sand southwards." This inspection, as it seems to me, shows that the area chiefly drained would be the great crystalline region—then doubtless more Alpine in character than now, the fragments of which are called the Scotch Highlands. Mr. Mellard Reade forgets that the detrital beds of this region (which were doubtless also undergoing denudation at this epoch) present no small resemblance to the Bunter Beds of England. Parallels to this argument may be found in the sandstones of the Carboniferous system in England, and in not a few cases in other lands.

(2) Mr. Mellard Reade falls into a second, though perhaps more natural, misconception in regard to my views as to the efficacy of tidal currents. My doubts as to their potency referred to their action *under the physical conditions of the English Trias;* that is, in an elongated gulf (adopting for a moment his hypothesis), to which, moreover, in all probability, the entrance was narrow and shallow. To discuss the whole question would extend this letter too much, but I must remark that citations concerning the action of the tide off the British Isles, where the physical conditions are very dissimilar, do not appear to me germane to the subject.

Next, as to the defect. Mr. Mellard Reade refrains from noticing my comparison of the Bunter of England to the Nagelflue and

Molasse of Switzerland, because "he has no personal observations to record" on them. But is not this in effect admitting that he is making wide generalizations on a rather limited experience, or, in other words, falling into an error too common among British geologists? But still more serious a defect is his silence as as to my main argument, which briefly stated is this: "I think I have a fairly good knowledge of British rocks; I can identify the majority of the Bunter pebbles (not of one rock species only) with rocks which occur *in situ* in the Highlands and as pebbles in later Palæozoic beds in Scotland down at least as far as Arran, but I have as yet failed to find them, either *in situ* or in older conglomerates in the southern half of England, or to discover a spot in which we may assume them to be hidden from our sight."

T. G. Bonney.

OBITUARY.

FRIEDRICH AUGUST VON QUENSTEDT.

Born 9th July, 1809; Died 21st December, 1889.

By the death of Prof. Quenstedt, Science has to mourn the loss of the Nestor of German geologists. He was born at Eisleben in Saxony, and after the death of his father, a member of the Gendarmérie of that town, he was adopted by his maternal uncle, a schoolmaster at Meisdorf; here he learnt Latin and music, and by the latter accomplishment managed to earn sufficient money to go to a University. He went to Berlin in 1830, and having overcome his uncle's wish that he should devote himself to theology, Quenstedt threw himself into the study of natural science and philosophy; he worked especially at crystallography and mineralogy under Wiess and Mitscherlich. After the conclusion of his University course, Quenstedt was appointed an Assistant in the Berlin Museum; his two principal papers published at this time were "Ueber Afterkrystalle des Serpentins" and "Die Entwickelung und Berechtung des Datholiths." In 1837 he was appointed Extra Professor at Tübingen, and in 1842 he was promoted to the full Chair of Geology, Mineralogy, and Palæontology. Here he laboured for more than fifty years, investigating the palæontology and geology of Würtemberg, building up the collection of the University, and popularizing the study of geology in the neighbouring district. That the last object was not the least in Quenstedt's ambition is illustrated by the fact that the first work he published in his new home was a small popular volume, "Schwaben, wie es war und ist." Immediately after his appointment at Tübingen, Quenstedt began the work on the Suabian Jurassics, with which his name will always be associated. His "Flözgebirge Württembergs" (1843) was the first fruit of his labours in this field. In order to compare this series with that of other areas, Quenstedt made a number of walking tours in France, North Italy, Savoy, etc. A serious illness of the lungs in 1859, due to over-exposure, compelled him to abandon these annual excursions; he had however already acquired the knowledge he sought, and his "Der Jura" had appeared in the previous year.

The "Petrefactenkunde Deutschlands" was Quenstedt's greatest work; the first volume was issued in 1849, and the eighth and last in 1884: it has been calculated that there are no less than 19,029 specimens figured and described in this work. Jurassic palæontology is especially well treated in the Petrefacta, and also in Quenstedt's "Handbuch der Petrefaktenkunde," the three editions of which appeared in 1852, 1867, and 1885 respectively; he made further contributions to the knowledge of the fauna of the same system in an extensive series of memoirs. The Cephalopoda was his favourite group: it formed the subject of both his first and last palæontological works, viz. his doctoral thesis in 1836, "De notis nautilearum primariis," and "Die Ammoniten des schwäbischen Jura," concluded a few months before his death. But though palæontology became the chief work of his life, as was naturally the case with a geologist living among the rich Jurassic rocks of Würtemberg, Quenstedt did not neglect his first love, mineralogy, and his "Methode der Krystallographie" (1840), his well-known "Handbuch der Mineralogie" (1854, 1863, and 1877), and his "Grundriss der bestimmenden und rechnenden Krystallographie" (1873), were his principal publications upon this subject. Probably no German geologist was more prolific of big books than Prof. Quenstedt, and the fact that he accomplished so much is no doubt to be explained by his retention in after-life of the indefatigable energy, the simple life, and abstemious habits, which characterized him in his student days. Born of the people, he was always in touch with them, and he never used the title "von," which had been granted him; his popular works, "Sonst und Jetzt" (1856), "Epochen der Natur" (1861), and "Klar and Wahr" (1872), showed how deeply he felt the need of the popularization of scientific education. His success in forming so valuable a collection from the Würtemberg Jura is probably as much due to the interest in geology spread by his writings as to his own personal popularity with the people among whom he lived so long and laboured so well.

MELCHIOR NEUMAYR.

Born 24th October, 1845; died 29th January, 1890.

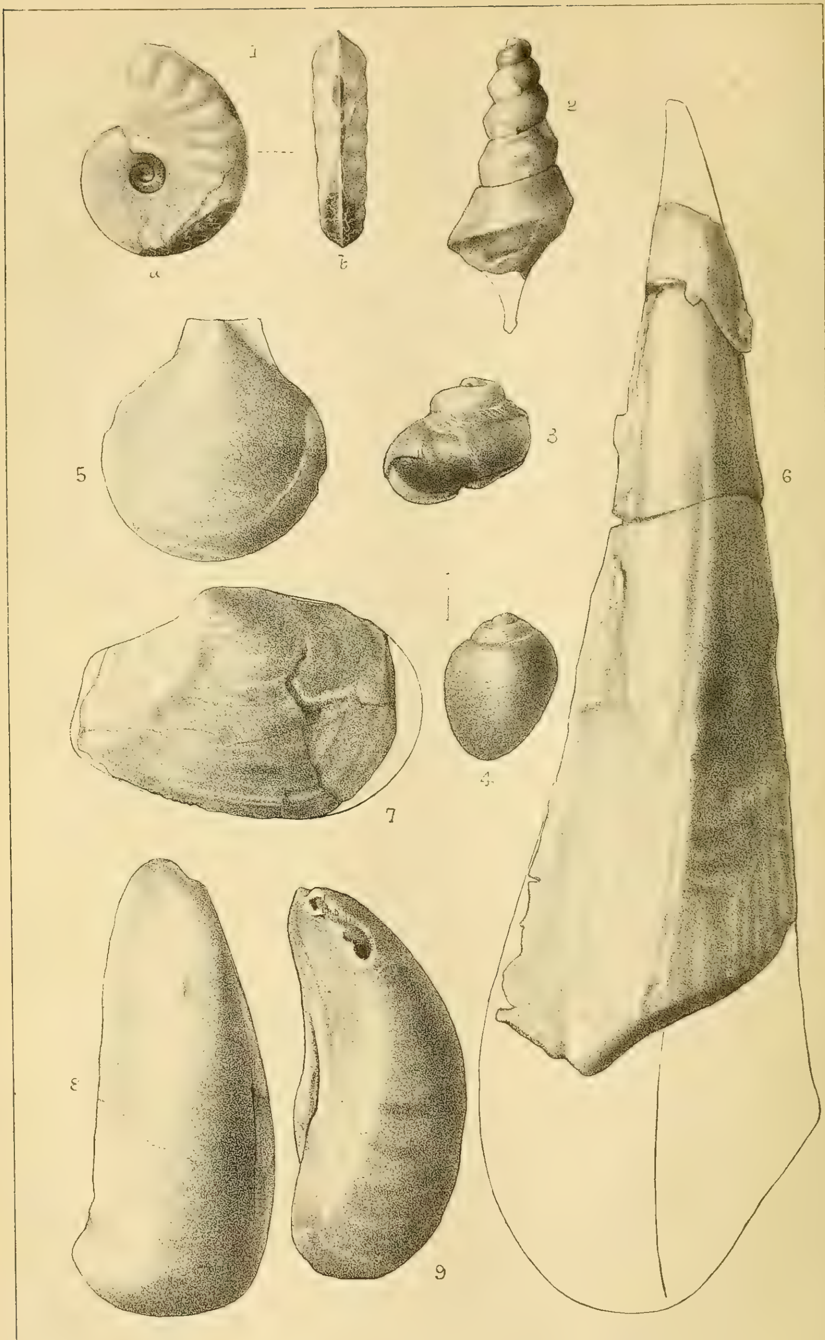
Melchior Neumayr was born in Munich on 24th October, 1845, but spent most of his childhood in Stuttgart, where his father was the Bavarian Ambassador. As the son of a family that has borne an honoured name in the annals of Bavarian history, Neumayr was destined for political service, and after leaving the Gymnasium of Munich, he commenced a course of legal studies in the University of that city. Here, however, his enthusiasm for science manifested itself, and led him to abandon law for geology and palæontology, the better to study which he proceeded to Heidelberg. After gaining his Ph.D. at this University, he returned to Bavaria, and worked under Gümbel on the geological survey of that state. After a few months' training he joined in 1868 the service of the Austrian Geologische Reichsanstalt as a volunteer; in the same year he issued his first paper in conjunction with Dr. Guido Stache on "Die Klippen bei Lublau und Jerembina." He soon secured an appointment on the paid staff of the Survey, on which he remained till 1872. He was engaged mainly in the Tyrol, the Vorarlberg, and the Carpathians, and it was no doubt the work during this period that fixed the bent of Neumayr's genius, as, after facing for four years the great geological problems connected with those districts, it was impossible for him to settle down as merely a laboratory palæontologist. At the same time Neumayr was not indifferent to the mountains for their own sake: he soon became a keen climber and an energetic member of the Deutscher und Oesterreich Alpin Verein; in spite of the many calls upon his time, he served for a year as secretary to this, the greatest of the Alpine Clubs, and only withdrew from the rolls of officers on his return to Germany in 1872. Though in later years heart disease prevented his active participation in Alpine work, he followed it with unflagging interest, and was to the last a fairly regular contributor to the Mittheilungen of the Deutscher und Oesterreich Alpin Verein.

In 1872 Neumayr resigned his post on the Austrian Reichsanstalt, and returned to Heidelberg; but in the succeeding year he was recalled to Vienna as Extraordinary Professor of Palæontology, a chair then created. In 1874 he made a geological excursion to Northern Greece and the Ægean; he climbed Athos and Olympus, and worked out and described the sequence of schists, gneisses and marbles of which the former mountain is composed. In 1879 he was appointed to the Ordinary Professorship at Vienna, a post he held till his death.

Though Neumayr's scientific work was executed in but little over twenty years, it was unusually fruitful in interesting results. His writings may be divided into three classes: First, his more popular works, such as his well-known "Erdgeschichte" (1887), and some of his papers on mountain structure, such as that recently issued on "Bergstürze." Secondly, his petrographical and stratigraphical papers beginning with his "Petrographischen Studien über mittleren und oberen Lias Wurtembergs" (1868 and 1870), and his "Dogger und Malm in Penninischen Klippenzug" (1869); besides a series on the Jurassic, there are his "Das Schiefergebirge der Halbinsel Chalkidike und der thessalische Olymp" (1876); and a valuable series giving the results of his Ægean tour, published in 1881; later still his paper "Die krystallinischen Schiefergebirge in Attika" (1884), shows that he always retained his interest in petrographical problems.

The papers of the third class, the more strictly palæontological, form a very lengthy list, touching on most divisions of the Animal Kingdom. The groups upon which Neumayr wrote most frequently were the Jurassic Cephalopods and the freshwater Mollusca of the Vienna basin; but valuable papers stand to his credit on the Foraminifera, Cœlenterata, and Echinodermata; his first memoir on the last group, "Morphologische Studien über fossilen Echinodermen," was an especially original and suggestive piece of work. Nor did he confine himself to the Invertebrates, for he wrote more than once on the Mammalia. Neumayr's knowledge of the Jurassic fauna and geology was exceptionally wide, and upon it was based the brilliant generalizations as to the zoological regions and climatic zones of that period, which mark out the series of papers commenced under the title of "Jura-studien" as his masterpiece. The "Stämme des Thierreichs" was the last of his larger works, and of this only one volume has been issued: in this he dealt with the Protozoa, Cœlenterata, Echinodermata, Vermes, and Molluscoidea, treating each group with a master-hand and in an original method. The second volume would have been even better, for if Neumayr could be charged with being a specialist, it would have been in connection with two of the classes there to have been discussed. He also projected an "Index Palæontologicus"; but this with many other plans of his has been frustrated by his death.

But though it may be convenient to group his work under these three divisions, Neumayr was too true a palæontologist for any rigid classification to be possible on such lines. Palæogeography was with him inseparably connected with palæontology, and his work on the former subject compelled him to keep abreast with the progress in other branches of geological work. Neumayr did not regard palæontology as a mere branch of zoology, and, keen evolutionist though he was, fossils had for him a higher value than that which they possess from their bearing on the origin of the existing fauna. He was, of course, interested in this aspect of the question, and probably no better work has been done in tracing descent among the invertebrates than his "Herkunft der Unionen" and his "Die natürliche Verwandtschaftsverhältnisse der schalentragenden Foraminiferen." But it would be unjust to Neumayr to regard him as a phylogenist alone, or to attach most value to his work in this field: the most original work in his "Stämme" was his reclassification of the Crinoidea, which marked a great advance when the compositor set it up; but it was out of date before the sheets had left the press. His discoveries in other subjects are of much more permanent value, and it is probably for these that he will be best remembered. He has, in fact, been recently described as a "palæogeographer" rather than a palæontologist, but this he would probably have regarded as a slurring limitation on his favourite branch of science. Neumayr's qualifications for the discussion of questions of the physical geography of the past were simply unique, and it is probably here that he will be most missed. Considering the powerful work of his early manhood, still more brilliant achievements might have been expected from the efforts of his maturer years. But the heart disease that had so long afflicted him struck him down in the very prime of life, just when his mastery of Jurassic palæontology, his thorough acquaintance with stratigraphical literature and his sound knowledge of the principles of physical geology, seemed most in demand for the solution of the problems that he knew so well how to handle.



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

South Australian Fossil Shells.

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ORIGINAL ARTICLES.

I.—Further Notes on some Mollusca from South Australia.

By W. H. Hudleston, M.A., F.R.S., F.G.S.

(PLATE IX.)

In the Geological Magazine for 1884[1] some Mesozoic fossils, obtained from near Mount Hamilton and the Peak Station, were noticed by me with figures and descriptions where the specimens were fairly well preserved. Since then additional specimens have been procured from adjoining districts.[2] The general character of the facies is fairly similar to that already noticed in 1884; but on the whole, perhaps, the specimens are scarcely so well preserved. According to the opinion of those who have had most experience, these fossils may be regarded as of "Cretaceo-Jurassic" age, though I am not aware that such undoubted Cretaceous forms as *Ancyloceras*, etc., have been discovered in the beds whence the fossils forming the subject of these notes have been derived.

With the materials before us, mostly in the state of casts, and sometimes only single specimens, a really good specific diagnosis is almost impossible. In those cases where I have ventured to give a name, it must be regarded as mainly for convenience of reference. To constitute species on a sound basis we require better specimens, and more of them, and these it is to be hoped that the collectors will ere long supply.

Ammonites fontinalis, sp.nov. Pl. IX. Fig. 1.

Shell compressed, carinated, involute. Owing to the raising of the umbilical margin the whorls are slightly concave towards the centre; umbilicus deep with steep walls, restricted yet showing portions of each of the inner whorls in succession. In the early whorls and more central portions of the body-whorl the ornaments consist of numerous fine flexuous lines, which have a tendency to pass out-

[1] Dec. III. Vol. I. p. 339 and Plate XI.

[2] The fossils described in this paper form part of a small collection of geological specimens which was exhibited in the South Australian Court of the Colonial Exhibition in 1886, and subsequently presented by Henry Y. Lyell Brown, Esq., F.G.S., Government Geologist for South Australia, to the Trustees of the British Museum (Natural History). They have now been figured and described at the request of Mr. H. Y. Lyell Brown. The collection comprises in addition, some Tertiary Plant-remains, some Tertiary Mollusca, and some Palæozoic Corals and fragments of Trilobites; the latter are from Yorke's Peninsula, and it is hoped that these will shortly be described with the kind assistance of Dr. G. J. Hinde, F.G.S., and other palæontologists.—Edit. Geol. Mag.

wards into reflexed ribs. In the body-whorl (of the only available specimen) these ribs become few in number and very broad, giving a very characteristic appearance to the shell: they do not appear to pass over the ventral (siphonal) area. The suture-lines are only exposed over portions adjoining the siphonal area, but where exposed are exceedingly distinct and well defined. There is a general roundness in the crenulations of the entire suture-line, which, on the whole, may be said to tend towards simplicity. The upper lateral saddle is not deeply cleft, whilst the upper lateral lobe is tridigitate, and almost on a level with the siphonal lobe.

The specimen is well preserved in a hard black argillo-calcareous nodule, which contains *Nucula*, *Cardium*, *Pinna*, *Serpulites*, etc., and the shell, which is highly nacreous, shows good iridescence. It was found at Primrose Springs, north of Lake Eyre, and is stated to be the first Ammonite discovered in South Australia.

This extremely compressed and carinated species, so far as external appearances guide us, has some resemblance to the *Murchisonæ* and *concavus*-group of Ammonites now referred to *Ludwigia* and *Lioceras*. The umbilicus in its step-like character strongly reminds us of the latter. On ascending higher in the geological scale, we are again reminded of such forms as *Am. Henrici*, d'Orb., and *Am. canaliculatus*, Münst. The Cretaceous species, so far as my experience goes, do not offer so many points of resemblance to the South Australian form.

It is worthy of remark that Ammonites have hitherto proved scarce in the Mesozoic deposits of Australia. Tenison Woods, writing in the year 1882 (T.R.S. N.S. Wales, vol. xvi. p. 150), remarks that only seven species had been recorded including the forms recognized by Moore. He described a new form under the name of *Am. olene*, which was said to resemble *Am. biflexuosus*, d'Orb., of the Great Oolite. Mr. R. Etheridge, jun., has figured five species of Ammonites in his "Queensland Palæontology" (unpublished).

Alaria or Anchura, sp. Plate IX. Fig. 2.

Anchura (Conrad) is a sub-genus of *Alaria* (monodactyl), where the wing presents a securiform bifurcation at the extremity. It seems confined to the Cretaceous, e.g. *Anchura carinata*, Mantell (Fischer, Man. Conch. p. 676).

Approximate length, without the "tail"	35 mm.
Spiral angle	23°.

The number of whorls is from ten to twelve; these are full and rounded in the early stages (the extreme apical whorls are unknown), carinated in the later stages; carina nearly median, and ornamented with short thick tuberculations; a second carina is sometimes displayed at the base of the whorls. Body-whorl angular, salient and bicarinated; the posterior carina very strong and prolonged into a stout digitation, the true termination of which is unknown. In some specimens the carinæ of the body-whorl are tuberculated, in others apparently not so. The sutures are rather open, so that the base of the whorls are partly uncovered. Other indications wanting.

This species occurs in black argillo-calcareous nodules at Primrose Springs. Some of the nodules are full of interior casts, with portions of shell substance adherent, but no casts of the exterior or of the appendages are available at present. Accurate diagnosis and strict comparisons are therefore difficult.

No species of *Alaria* is enumerated in Moore's "Australian Mesozoic Geology"; but Mr. Etheridge, jun., figures *Anchura Wilkinsoni* (Queensland Pal. pl. 31, figs. 4 and 5), which is shorter, possesses a wider spiral angle, and has more slender costæ on the carina of the whorls of the spire than is the case with our species, which I consider to be different. On the other hand, our species presents many points of resemblance to *Anchura carinata*, Mantell, of the Gault. Indeed, if they are not the same species, they are very closely allied; and as I only have access to a cast of the one and to shells of the other, a true comparison is impossible. If we had any evidence of the securiform termination of the wing in the Australian fossil, I should be almost disposed to pronounce in favour of its identification with *Anchura carinata.*

Turbo ? sp. Plate IX. Fig. 3.

The length is about 20 mm.; width rather more, and the spiral angle nearly a right angle. The shell is turbinate, and has three or four whorls, which increase regularly, and do not, as far as may be judged from the cast, present any marked tabulation. Portions of the different shell-layers are preserved, the inner ones exhibiting a considerable amount of nacre. There are no certain indications of external ornament, though the general aspect might suggest a smooth exterior. Traces of a sutural canaliculation are also visible. The aperture is imbedded in matrix, but appears to be circular.

But for the apparent depth of the sutural canaliculation and its larger size, the general aspect of this shell suggests that it belongs to the group of "*Turbo*," which is characterized by *Turbo* (*Nerita*) *lævigatus*, Sow., and which group has been likewise successively referred to *Monodonta*, *Chrysostoma*, and to *Ataphrus*, Gabb. It may be worth noticing that *Turbo lævigatus* was enumerated by Moore from the Greenough district in West Australia.

A single specimen is known from Primrose Springs.

Actæon or Avellana, sp. Pl. IX. Fig. 4.

Length $6\frac{1}{2}$ mm.; body-whorl about four-fifths of the total length; spire subdepressed, and consisting of about three whorls, increasing under a wide angle. Body-whorl relatively very large, and more ventricose posteriorly than in front. The ornaments consist of regular deep-set punctate furrows, spirally arranged, which leave their impress on the cast of the body-whorl, where they are about twenty-four in number. Aperture broadly ovate, and about two-thirds the length of the shell. Columella much excavated, and showing on the cast the mark of one fold situated anteriorly. Other indications wanting.

There being no shell whatever on the body-whorl, it is difficult to fix the genus with certainty. The general aspect of the cast, and especially the deep-set punctate furrows, remind us of *Avellana*, whilst the single fold on the columella is in favour of *Actæon*. Cf. *Actæon depressus*, Moore, Q.J.G.S. vol. xxvi. p. 256, pl. x. fig. 20, and R. Etheridge's Queensl. Pal. pl. 29, fig. 9.

A single specimen, probably from Primrose Springs.

PECTEN, sp. Pl. IX. Fig. 5.

Form orbicular and depressed, umbones pointed, auricles moderately unequal. The shell appears to have been nearly smooth, and the ornamentation was confined to concentric lines.

It is somewhat more orbicular than *Pecten socialis*, Moore (vol. *cit.* p. 248, pl. xi. fig. 9). There is a certain general resemblance to *Pecten orbicularis*, Sow., and in a less degree to *Pecten demissus*, Phil.

A single specimen from Hamilton Station near Lake Eyre.

PSEUDAVICULA ANOMALA, Moore, 1870.

1870. *Lucina anomala*, Moore, Q.J.G.S., vol. xxvi. p. 251, pl. xiv. f. 4.
1884. *Avicula orbicularis*, Hudl., GEOL. MAG. Dec. III. Vol. I. p. 341, Pl. VI. Fig. 10.
1890. *Pseudavicula anomala*, Moore, Queensland Palæontology, pl. xxiv. fig. 13.

Mr. Etheridge, jun., is probably right in assuming that *Avicula orbicularis* is a synonym of *Lucina anomala*, though Mr. Moore was very wide of the mark in referring an aviculoid shell to the genus *Lucina*. As the diagnosis of *Pseudavicula* is not known to me, I am not able to point out in what respect it is held to differ from *Avicula*.

If Mr. Etheridge is correct in identifying *Lucina anomala* and *Avicula orbicularis*, the species occurs both in Queensland and in the Lake Eyre District (South Australia).

PINNA AUSTRALIS, sp.nov. Plate IX. Fig. 6.

Estimated length, 160 mm.; full width in front 45 mm. Shell elongate, narrow, deep; section in front sub-rhomboidal. Dorsal margin nearly straight, ventral margin but little sloped, and slightly incurved. Each valve is unequally divided by a longitudinal ridge, in which is impressed a sulcus forming a line of weakness resulting in actual fracture towards the front. Shell substance rather thick. The ornaments consist of numerous straight longitudinal ribs along the narrow dorsal area, whilst on the wider ventral area the ribs are broader and more curvilinear.

The materials for a full diagnosis are of necessity wanting where so little of the shell has been preserved; but there seems some justification for constituting a new species in this case. The form is less wedge-shaped than *Pinna cuneata* of the Oolites, and in some respects more nearly approaches *Pinna tetragona*, Sow. (M.C. t. 313, f. 1), where the valves are even more carinated than in this one, and where the section consequently is more thoroughly tetragonal. Our species therefore may be regarded as intermediate between the cuneate and tetragonal forms of *Pinna*.

No species of *Pinna* has hitherto been described, so far as I am aware, from Australia, but there is a fragment of a large *Pinna* figured in Queensland Palæontology, pl. 20, figs. 16 and 17, and reference made to *P. laticostata*, Stol., Cret. Rocks India, Pelecypoda, Pal. Indica, vol. iii. 1871, p. 385, pl. xxv. fig. 2–3, and xxvi. fig. 4. The specimen figured is from a sandy bed at Primrose Springs.

MYTILUS, sp. Plate IX. Fig. 9.

This is a true *Mytilus*, the umbones being terminal. It is distinguished by the marked convexity of the upper or hinge border and a corresponding incurvation of the lower margin. There is no shell left; but, to judge from indications on the cast, broad concentric lines constituted the principal ornamentation.

This cast is perhaps somewhat too compressed for *Mytilus rugocostatus*, Moore, and both margins are rather arcuate.

There are no indications as to locality with this specimen, which probably comes from the Lake Eyre district.

MYTILUS LINGULOIDES, Hudleston, 1884.

1884. *Modiola linguloides*, Hudl., GEOL. MAG. Dec. III. Vol. I. p. 341, Pl. XI. Fig. 6.

I take this opportunity of pointing out that *Mod. linguloides* is really a *Mytilus*. Large specimens of this species occur 45 miles South-West of Coattonoona Station in the Lake Eyre district. It may possibly be the same as *Mytilus inflatus*, Moore, (*op. et* vol. *cit.* p. 252, pl. xiii. fig. 4), but would seem to run larger and to be somewhat less inflated than Moore's species.

MODIOLA SUBSOLENOIDES, sp.nov. Pl. IX. Fig. 8.

Length from umbones to lower border about 55 mm. Umbones rather blunt; umbonal ridge much thrown back towards the dorsal or hinge-border. Shell subelongate and gibbous; anterior area straight and marked by rugose concentric lines, which are much less strongly developed in the dorsal or hinge area, which slopes from the umbo, and curves round to meet the posterior extremity. This latter is considerably dilated, being $2\frac{1}{2}$ times the width of the anterior extremity.

This species possesses considerable resemblance to *Myoconcha*, but the shape of the umbones and the subnacreous character of the inner layers of shell are against this supposition. In figure it possesses a general resemblance to "*Mytilus*" *solenoides*, Morris and Lycett (Great Oolite Moll. Biv. p. 38, pl. iv. fig. 1).

No locality is recorded, but it probably comes from the neighbourhood of Lake Eyre.

THRACIA PRIMULA, sp.nov. Pl. IX. Fig. 7.

Length to width about as 5 : 3·5. Shell extremely thin, subovate, and but slightly inequivalve, extremely compressed. Umbones a little posterior, and giving rise to a slight curvilinear ridge in the posterior area. Anterior side suborbicular, posterior extremity squarely truncate. Breadth of anterior to posterior side as 3 : 2. The ligament is well developed, and occupies one-third of the length of the posterior dorsal margin. Rather broad concentric lines of growth ornament the shell.

This species resembles *Thracia Wilsoni*, Moore (vol. *cit.* p. 254, pl. xiv. fig. 8, figured as *Corimya Wilsoni*, Moore, in Quensl. Pal. pl. 28, figs. 10, 11). It is chiefly distinguished from that shell by the difference between the anterior and posterior breadth, and possibly also by its smaller habit of growth.

Locality.—Primrose Springs, north of Lake Eyre.

EXPLANATION OF PLATE IX.

SOUTH AUSTRALIAN FOSSILS.

FIG. 1. *Ammonites fontinalis*, sp.n. Primrose Springs, Lake Eyre.
,, 2. *Alaria* (? *Anchura*) sp. cf. *Anchura carinata*, Mantell. Primrose Springs.
,, 3. ? *Turbo*, sp., cf. *Turbo lævigatus*, Sow. Primrose Springs.
,, 4. *Actæon* or *Avellana*, species. ? Primrose Springs.
,, 5. *Pecten*, species. Mt. Hamilton Station, near Lake Eyre.
,, 6. *Pinna australis*, sp.n. Sandy bed at Primrose Springs.
,, 7. *Thracia primula*, sp.n. (right valve). Primrose Springs.
,, 8. *Modiola subsolenoides*, sp.n. No locality.
,, 9. *Mytilus*, sp. No locality.

II.—THE EXTENSION OF THE MELLARD READE AND C. DAVISON THEORY OF SECULAR STRAINING OF THE EARTH TO THE EXPLANATION OF THE DEEP PHENOMENA OF VOLCANIC ACTION.

By H. J. JOHNSTON-LAVIS, M.D., B.-ès-Sc., F.G.S., etc.

FOR many years my thoughts have been occupied with the phenomena of eruption at or near the surface, and although a detailed study of the Vesuvian volcano and its products gave me the key to the mechanism of eruption and injection of igneous matter near the surface, I was always at a loss to understand, on the older theories, how lava could ever start upwards in fissures.

It has been said that volcanic action was the cardinal point upon which hung the hypotheses and theories which have been or may be offered in explanation of those geodynamical problems which are the very basis of geology. Six years since, that group of phenomena which constitute eruptive activity at the surface of our planet were recognized as due to the presence of elastic vapours contained within the fused rock; but no ideas had been offered, and still less any law formulated, of the introduction into and separation of these volatile constituents from the igneous magma which is the cause of all the modifications of eruptive actions as we see it. In my paper on the Geology of Monte Somma and Vesuvius, the conclusions I had been led to by the study of that volcano, as illustrating surface eruptive phenomena in general, were given and the paper was terminated by 50 propositions which appeared to me as being supported by those studies.[1] After my further investigations at other volcanoes, finding an overpowering abundance of confirmatory evidence, those conclusions were united in another paper of mine read before the Geological Society on April 29th, 1885, entitled, "The Physical Conditions involved in the Injection, Extrusion, and Cooling of Igneous Matter," and which enunciate the physical laws

[1] These conclusions and propositions, contrary to my wishes, were not allowed to appear in the memoir at the time it was published, Q.J.G.S. Feb. 1884.

governing eruptive action." This paper, for some unknown reason, was suppressed; but in 1886 it was at last published in the "Proceedings of the Royal Dublin Society." That memoir, though so much delayed, has precedence of the interesting studies of Lagorio, and recently of Iddings.

Although these preliminary statements might appear as outside the present subject, they are not so; for it is necessary to separate absolutely the *superficial* from the *deep phenomena* of the eruption of igneous matter, and reference to those papers should be made, so that it may be seen that there such distinction has been made, and a full explanation of the superficial ones given. What was assumed as necessary to that explanation was, if required, an unlimited amount of igneous matter coming from below. It is just this assumption that is now to be discussed in the light of the new theory of secular straining of the earth which I contend will give the first clear and satisfactory explanation of *deep volcanic action.*

In the old theory of the earth-crust crumpling over a contracting and cooling nucleus, fluid or partially so, it always appeared to me to be inexplicable how fluid matter could be squeezed out, or why all the fluid on the surface of the earth did not rush down to fill up any vacancy that the contracting interior tended to produce.

This perhaps is expressing the facts in simple commonplace terms, but is sufficient to illustrate the incompatibility of this hypothesis with the fact of some of the liquid interior of the earth rising through fissures towards the surface.

The hypothesis that tangential thrust did not exist, but that the earth-crust was shrinking and compressing an entire or partial fluid nucleus, would have satisfied the vulcanologist, but is absurdly contrary to the incontrovertible evidence of tangential compression, as seen in the plications and overthrusts existing upon the whole surface of the globe.

The Mellard Reade and Davison theory is reasonable in itself, and satisfies alike the student of mountain building and the vulcanologist. Prof. O. Fisher's criticisms at first sight seem rather serious to the theory itself; but when we consider the most flimsy nature of the data of the age of our earth, the temperature of solidification and the rate of cooling, we may safely say that the mathematician has yet to have his day. Besides this, even the nature, and still more the conductivity of all rocks beyond two miles from the surface is unknown.

The new theory tells us that the shells from the uncooled nucleus out to the zone of maximum cooling lose more and more heat; and their tangential strain increases—a condition in fact identical with the guns built up of steel rings, shrunk on, one above another. The tendency of all the shells beneath the no-strain zone is not only to crumple all above it, but to compress the uncooling nucleus; but when that compression has reached its maximum limit, equilibrium can only be restored either by fluxion stretching or shearing (how about foliation) or fracture. This fracturing would tend to be fusiform in section (I am open to correction) with the maximum separation of the sides at the zone of maximum cooling, with one extremity reaching on one side to the uncooling nucleus, and on the other to the zone of no-strain. But the compression exerted on the nucleus by the shells beneath the no-strain zone would cause any part of it sufficiently fluid to rise and inject this fissure. In consequence of this, we should have a mass of igneous matter that would have become more fluid by diminished pressure connected by a narrow neck below at the lowermost shell of cooling, but its maximum bulk at the zone of maximum cooling, whilst its most excentric or uppermost prolongation would reach the *zone of no-strain.*

Now the shrinking shells beneath the *no-strain layer* will tend to draw to and within themselves the water squeezed out of the crushed shells above the *no-strain layer,* and this would be particularly marked at *the zone of no-strain,* and just below it where we have seen the outermost limits of the fissure injected with igneous matter reaches. In other words, we have highly heated magma in contact with the aquiferous strata, the conditions required in the memoirs referred to to explain the whole of the remaining or *superficial* eruptive phenomena. The compression of the shells above the *no-strain* zone will tend to prevent the progress of the magma in the upper part of the fissure towards the surface as it increases in tension by the gradual absorption of water from the surrounding rocks. This resistance is at first slight, because the lowermost shells near the *no-strain* zone are interested where the compression or crushing is at its minimum, as, however, the magma gradually bursts its way by prolonging the fissure further and further towards the surface, the increased resistance is counterbalanced by the increased supply of water and consequent solution thereof, so that the tension of the magma may rise more rapidly, and also by the crushing and compression being resolved into crumpling and shearing at the free surface of the earth.

I do not for one moment suppose that every fissure that forms becomes eventually a chain of volcanoes for conduction, convection, etc., balanced against initial temperature of magma, and many other circumstances may be such as to bring about solidification.

This constant compression of the terrestrial nucleus would have the effect on the one hand to tend to its solidification. Even were the whole of the earth's interior solid, the moment the tearing asunder took place in the lowermost shells underlying cooling and contraction, the relief of pressure on the nucleus in the neighbourhood of the newly-formed fissure would no doubt be sufficient to allow the solid to pass into a fluid state. Individually, I cannot persuade myself that even if the uncooling nucleus of the earth is not fluid, or its outer surface fluid, yet there must be large intratelluric reservoirs of fluid rock. One of the principal reasons of this is that over large areas we find some dominant chemical character of the essential volcanic products, the only sure guide to a common origin of igneous rocks. No more striking example could be cited than Italy, where potash is practically always the dominant alkali in all the volcanoes of that country, the presence of which is difficult of explanation in any other way than as an original constituent of the primitive magma. Silica, lime, magnesia, iron, alumina, and even soda, might be explained when abundant, as being taken up from the rocks traversed, but this is not the case with potash.

Lastly, this theory will explain that constant, continuous, though small supply of magma that is necessary for the never-ending ejections of Stromboli, or the dribbling of lava that goes on almost uninterruptedly at Vesuvius.

At any rate, it seems that we have in this theory a more satisfactory explanation of terrestrial phenomena acceptable alike to the tectonic geologist as to the vulcanologist.

III.—Notice of New and little known Fish Remains from the Blackband Ironstone of Borough Lee, near Edinburgh.

No. VI.

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

Ctenodus interruptus, Barkas.

Ctenodus interruptus, T. P. Barkas, Scientific Opinion, vol. ii. 1869.
,, ,, A. S. Woodward, Ann. Rep. Yorks. Phil. Soc. 1889, pl. i. f. 2.

THIS interesting species has hitherto been known only by the single type-specimen, a mandibular tooth, contained in the York Museum, originally described by Mr. T. P. Barkas, and recently very correctly redescribed as well as figured by Mr. A. Smith Woodward. It so happens that some years ago a considerable number of these teeth, both mandibular and palatal, occurred in the Borough Lee ironstone: my own collection contains no less than forty specimens, and there are many others in the Museum of Science and Art, so that I may now add considerably to the knowledge of the species.

Mr. Woodward finishes his description as follows:—"As remarked by Mr. Barkas, the tooth thus described is distinguished from the teeth of the most nearly allied species, *C. cristatus*, by the comparative smoothness of the inner moiety of each ridge, and by the distinct separation of the much compressed denticles." But the York specimen is only one of a very variable series of forms, and, of the characters here given, only one is constant, namely, the compression of the denticles in a direction at right angles to that of the ridges. Sometimes this character is only very distinctly marked at the outer margin of the tooth-plate, or on its posterior two-thirds, but it is nevertheless seen with absolute constancy in all specimens in which the denticulation is not entirely removed by abrasion, as is sometimes the case. The "comparative smoothness of the inner moiety of each ridge," though a frequent, cannot be said to be a constant character, as I have specimens both mandibular and palatal in which the ridges are denticulated up to their origins, while on the other hand the ridges may be almost entirely smooth until close to the outer margin of the tooth. It is clear that this condition, instead of being specific, is entirely dependent on the amount of abrasion to which the tooth has been subjected in performing its masticatory functions; for as a general rule it is less marked in the smaller than in the larger specimens. And also, as a rule, the palatal teeth seem to have suffered more from this tear and wear than the mandibular ones.

Ctenodus interruptus is still more variable in its form than *Ct. cristatus*; in fact hardly two of the numerous specimens which I have seen can be said to be alike. Some are proportionally longer, others broader in their shape; in some the ridges are more transverse, in others more radiating in their direction, and, as above noticed, the extent to which the ridges are tuberculated displays a wide range of variation. The number of ridges on the type-specimen is fourteen, two being intercalated at the margin; but the usual number upon the mandibular tooth is eleven or twelve, though in one case they are reduced to nine. Bifurcation or intercalation of the ridges is also common in mandibular teeth, and indeed at the posterior extremity of the tooth-plate they often appear altogether broken up into groups of tubercles. In the palatal teeth the ridges are usually more regular, and their number varies from twelve to fifteen. A portion of the hinder part of the cranial roof shows that the median occipital plate was pointed in front, as in *Ctenodus cristatus.*

Although it is not difficult to tell a specimen of *C. interruptus* from one of *C. cristatus* by the general appearance, and indeed at the first glance, it is nevertheless by no means easy to put into words a set of characters which shall absolutely separate the two from each other. The only absolutely constant feature of *C. interruptus* is the compression of the denticles in a direction at right angles to the ridges; but I have before me now a mandibular tooth of *C. cristatus* from Newsham which does also to a *slight* extent exhibit that character as well as the comparative smoothness of the inner moiety of the ridges. And it must also be pointed out that the "type" specimen is not very *typical* in its shape, as the majority of specimens have a considerably greater resemblance to *C. cristatus.* I have therefore been for years in a state of doubt as to whether *C. interruptus* should be retained as distinct, but the absolute constancy of the peculiar compression of the outermost denticles in all those Lower Carboniferous specimens certainly seems to be a justification for calling them by a different name from that of their close relatives in the Coal-measures.

The type-specimen of *C. interruptus* is said to be from Gilmerton; it is contained at all events in a piece of undoubted Scotch Lower Carboniferous ironstone. I have, however, never myself met with a specimen in the Gilmerton ironstone, though that of Borough Lee and Loamhead has yielded so large a number. It occurs also in the Carboniferous Limestone series at Kinghorn, Fifeshire; in the Calciferous Sandstone series at Pittenweem in the same county; and at West Calder, Midlothian. In the west of Scotland it has occurred in the ironstone of Barkip, Dalry (Carboniferous Limestone series), specimens from that locality existing in the collections of Mr. R. Craig Beith and Mr. John Smith.

Hemictenodus, Jaekel.

In a recent paper[1] Dr. Otto Jaekel has proposed to institute the genus *Hemictenodus* for *C. obliquus* of Atthey and a species from the German Trias. This new genus he characterizes by the small number of ridges on the teeth, as compared with those of such a form as *Ctenodus cristatus*, and considers it to be intermediate between *Ctenodus* and *Ceratodus*, in fact an illustration of the evolution of the one genus from the other. Into the latter aspect of the question I cannot follow Dr. Jaekel, as I consider the gap between *Ctenodus* and *Ceratodus*, in spite of the opinions of Prof. Anton Fritsch, to be far too wide to be bridged over simply by a comparison of shapes of teeth. The consideration as to whether *Ctenodus obliquus* may not be adopted as the type of a new genus is, however, quite another matter.

In briefly describing portions of cranial shields of *Ctenodus* from the Northumbrian Coal-field, Messrs. Hancock and Atthey[2] drew attention to the fact that in the species *obliquus* the median occipital plate was concave in front, while in *tuberculatus* (= *cristatus*) it "projects, and has a wedge-shaped process in the centre." And an undoubted skull of *Ct. cristatus*, belonging to Mr. Ward, F.G.S., of Longton, and figured in outline by Prof. A. Fritsch, shows that in point of fact the median occipital plate was pointed in front, and related to the neighbouring plates as in *Dipterus*, the anterior pair of the three pairs of plates, which border it on each side meeting in the middle line in front of it. A different arrangement is, however, shown in the skulls figured by Mr. T. P. Barkas[3] and Prof. Miall,[4] in which the median occipital has the anterior concavity as in the specimens attributed to *obliquus* by Hancock and Atthey, and to this concavity articulates a second median plate of considerable size, which entirely separates the anterior pair of lateral bones from each other. That the skulls showing this arrangement belong to a group typified by *C. obliquus* there can be no doubt, any more than that the other pattern is characteristic of *cristatus* and such allied forms as *interruptus*. The question comes to be,—Is this distinction *generic*? I think so myself, though, as in other cases, it may not seem so to other minds differently constituted.

Hemictenodus quinquecostatus, Traquair.

Ctenodus obliquus, var. *quinquecostatus*, Traquair, Geol. Mag. Dec. II. Vol. X. December, 1883.

Owing to the general resemblance which the teeth of this species bear to those of *C. obliquus* I originally described it as only a variety of that form, but the constancy of the smaller number of ridges induces me to elevate it to the rank of a species. In *H. obliquus* the usual number is six to eight; here the regular number is five, with only rarely a rudimentary sixth one.

The top of the skull shows the same general arrangement of

[1] Sitzungsb. der Gesellsch. naturforschender Freunde in Berlin, 1890.
[2] Ann. and Mag. Nat. Hist. (4) vii. 1871, p. 193.
[3] Manual of Coal-measure Palæontology. [4] On some bones of *Ctenodus*.

plates as in *H. obliquus*, though the median occipital plate seems proportionally rather larger and broader, and the second median plate in front of it rather smaller. Many specimens have occurred showing the body of the fish, but unfortunately usually in a rather jumbled condition; a comparison of those specimens, however, pretty plainly shows that the general shape was like that of *Ceratodus*, as I long ago pointed out was the case in *Ctenodus* (= *Campylopleuron*[1]), namely, that the tail was protocercal, and a long continuous dorso-caudal fin present.

Uronemus splendens, Traquair.

Ganopristodus splendens, Traquair, Geol. Mag. Dec. II. Vol. VIII. Jan. 1881, p. 37; and Vol. IX. Dec. 1882, p. 543.

I have previously alluded to the resemblance in the teeth and in the shape of the body which this species bears to the little *Uronemus lobatus* of the Burdiehouse Limestone; resemblances which have impressed me so much of late that I have resolved, in the meanwhile at least, to give up *Ganopristodus* and add the species to *Uronemus*. Here I may also state that I have years ago abandoned *Uronemus magnus* from the Airdrie Blackband Ironstone, as I believe the fossil to which I gave that name[2] to be a fragment either of *Ctenodus* or *Hemictenodus*.

Uronemus, if the species *splendens* be adopted as an exponent of its structure, is a genus of great interest, as it shows us a fish which we may safely put among the Dipnoi, but whose dentition does not take the form of Ctenodont or Ceratodont plates. Nevertheless the teeth of *Uronemus* closely resemble in general appearance the denticles on the coronal ridges of *Dipterus*, and of young specimens of *Hemictenodus obliquus*.

Since my last notice of this species was written I have obtained several specimens of the cranial roof, from which it turns out that the constituent plates were arranged much as in *Dipterus* and *Ctenodus cristatus*. The median occipital is in contact with three lateral pairs of plates, the anterior pair meeting in the middle line in front, and there is another very small median plate in front of this pair, but separated from the median occipital by a considerable interval.

IV.—Note on the Airolo-Schists Controversy.

By the Rev. A. Irving, D.Sc. (Lond.), F.G.S.;
of Wellington College, Berks.

FROM one cause and another efficient education in modern languages has been exceptional in this country until quite recent years; and so it is no reproach to the geologist for him to have to confess that he "can't read German." He must therefore get some friend to translate for him, or wait until translations of many important papers and books are published; and in many cases this never happens. So it is thought that towards the present controversy, which has been raised about the schists, etc., of the Val Bedretto and the adjoining districts, the mental attitude of many

[1] Nature, 1878.
[2] Geol. Mag. Dec. II. Vol. I. 1874, p. 555.

geological students may be pretty much that of the Bavarian veteran.[1] It is with the hope of throwing a little light on the subject that the present writer has put pen to paper. For it is not too much to say that the subject is one of critical importance.

The appearance of Dr. Heim's great work[2] on the Tödi-Windgällen Group of the Central Alps marked almost a new departure in the investigation of the forces employed by nature in mountain-building. In some of his theoretical views drawn from the facts described in that work Heim had been anticipated by Prof. Suess of Vienna,[3] and the priority is generously acknowledged. The work is well known; but the student needs to be warned against the false inferences on some points which he will probably draw from the sectional descriptions in the *Atlas*, if he omits to study the corresponding portions of the text of the work. If anything could exceed our admiration for this splendid contribution to physical geology, it might be that which we all felt for the magnificent series of transverse sections of the Alps—the work of Prof. Heim and his pupils at Zürich—exhibited in the temporary Museum of the International Geological Congress at Burlington Gardens in September, 1888. In his recent little work[4] the present writer has discussed many of the facts furnished by Dr. Heim in their bearing upon questions connected with the metamorphism of rocks. In his Essay on the Crystalline Schists,[5] in 1888, Heim indicates clearly the extent to which he is prepared to go in applying the principles of 'dynamo-metamorphism.' He expressly warns geologists against rash generalizations in the direction of "regional pressure-metamorphism," from the exceptional and abnormal structural facies presented by those Alpine masses, which he knows most intimately, and has described in such a masterly way in his great work. It is unnecessary to occupy space here with quotations, since a translation of Dr. Heim's essay has been published.[6]

Dr. Heim's letter, a translation of which was read by Dr. Geikie at the meeting of the Geological Society on the 22nd of January, 1890, seemed to contain little but what those who had made a study of his great work were familiar with before. But if it served no other purpose, the publication of that letter is most opportune as a reply to some remarks in a recent Number of the GEOLOGICAL MAGAZINE.[7] J. J. H. T. may learn from it that, by the Swiss geologists at least, the "primitive crust of the earth" is not by any means regarded as a "geological Will o' the wisp." Dr. Heim's own

[1] "It was the English," Kaspar cried,
"Who put the French to rout;
But what they fought each other for,
I could not well make out."

[2] *Untersuchungen über den Mechanismus der Gebirgsbildung.*

[3] *Die Entstehung der Alpen*, a work of great value and interest.

[4] *Chemical and Physical Studies in the Metamorphism of Rocks* (London, 1889).

[5] See *Etudes sur les Schistes Crystallins*, published by the International Geological Congress (London, 1888).

[6] See *Nature*, vol. xxxviii. Sept. 27, 1888.

[7] Decade III. Vol. VII. (January, 1890), p. 36. Prof. de Lapparent's *L'Ecorce Terrestre* (Brussels, 1888) is worthy of consideration.

formulation of his ideas on this subject in this letter shows that he has seen no reason to depart in any essential matters from the diagnostic contrast, which he drew some twelve years ago, between the rocks of the *Central Massif* (viewed as a great crystalline complex) and the rocks of the flanking ranges of the Alpine Chain.[1] Von Hauer (as representing the Austrian geologists) and Credner (as representing those of Germany) may be cited in favour of the same view. So that one is at a loss to understand what people can mean, when they attempt to depreciate the results of the microscopic and field work of such a worker as Prof. Bonney by charging him with "holding exceptional views,"[2] in maintaining the existence of a great Archæan complex with an individuality (so far as the broad general facies are concerned) altogether its own, in contrast with any great *complexus* of rocks of later age. Why even Heim does not venture to speak of the Palæozoic rocks of the Tödi-Windgällen Group (as a series) as anything more than 'half-crystalline';[3] yet this is perhaps the most powerfully compressed and contorted region of the whole Alpine system. Eliminate the local and exceptional structural features which are met with, resulting in some cases from contact-metamorphism, sometimes from excessive pressure and shearing (*e.g.* in the Tödi-Windgällen Group), at others from the detrital material derived from the central crystalline massif being exceptionally siliceous and crystalline,—and you get a great sedimentary series flanking the whole Alpine Chain quite distinct from the Central Massif. This seems to be Prof. Bonney's view; and this the foremost of living Swiss geologists has declared to be the view still held by him and his *confrères* in the year 1890.[4] And so the authors of this flank-attack upon Dr. Bonney's work seem to have impaled themselves upon the horns of a pretty dilemma! This is certainly rather 'sensational' for them.

Now it must be distinctly borne in mind that Heim's descriptions of the rocks of the Central Alps are almost entirely based on *macroscopic* examinations and field observations; and he himself emphasizes the desirability of a detailed (durchgehend) *microscopic* examination.[5] *This it is which forms the chief strength of Prof. Bonney's position.* For the Swiss geologists are rather late in the field with this branch of research; and, while they have been lagging behind, other cases of alleged "reduction of rocks of later date to the condition of crystalline schists,"[6] have been exposed and condemned on a closer examination with the microscope.[7]

The late Prof. R. D. Irving[8] defined a typical crystalline schist as "a rock of completely crystalline interlocked texture, which is

[1] *Op. cit.* Bd. ii. p. 40. See also *Chem. and Physical Studies*, pp. 89, 124.

[2] Q.J.G.S. February, 1889, p. 109.

[3] *Op. cit.* Bd. i. pp. 41–52.

[4] From a conversation which the present writer had with Dr. Heim over his sections in September, 1888, it has seemed all the way through this controversy that the real difference between Heim and Bonney has been much exaggerated.

[5] *Op. cit.* Bd. i. p. 43.

[6] Q.J.G.S. *loc. cit.*

[7] See (*e.g.*) 'A supposed case of metamorphism of an Alpine rock of Carboniferous age,' Geol. Mag. Decade II. Vol. X. pp. 507-511.

[8] *Etudes sur les Schistes Crystallins*, p. 93.

possessed of a schistose parting due to a parallel or foliated arrangement of the mineral ingredients, or of aggregations of those ingredients." This is about as satisfactory a definition as has yet been given. And he complains[1] that after the name 'metamorphism' was applied to undoubted masses of a clastic origin which had acquired a certain amount of schistosity ("a vague naming of an unexplained process rather than an explanation"), it was loosely and generally carried over to all classes of crystalline schists, whether anything was known about their original condition or not.[2] "No serious effort was made to trace them into unquestionable sedimentaries, and when the attempt was made later it was found impossible to do so." When then we begin to discuss a 'crystalline schist,' we are treading on slippery ground, unless we agree on some definition beforehand. We cannot tolerate the construction of a definition to suit the exigencies of a special case; yet it is not too much to say that Mr. Teall was caught in this fallacy in the discussion of Prof. Bonney's paper, at the Geological Society, on 22nd January, 1890.[3] He enumerated certain characters, which the altered Belemnite-bearing rocks of the Nufenen Pass exhibit under the microscope; but they do not satisfy the requirements of such a definition of a crystalline schist as has been quoted above. At the same time he frankly admitted that he had found on examination that "the garnet-schists are quite different from the Belemnite-rock." No one can therefore doubt that Prof. Bonney was standing on very firm ground when he "gave a complete contradiction to any statement that these fossil-bearing rocks are in any proper sense crystalline schists," and asserted that the similarity between these and certain undoubted crystalline schists of Val Canaria and Val Piora was only superficial, as "under the microscope the differences were at once visible," the two series of rocks having a totally distinct facies. All the details of the evidence on which these statements are based will appear when Dr. Bonney's paper is published.[4]

If we may judge from one of the first instalments of detailed work in microscopic petrography which the younger school of Swiss geologists have produced, we have certainly in the recent monograph of Dr. Grubenmann, of Frauenfeld,[5] the earnest and the promise of a rich harvest in microscopic petrography in the near future. There is a thoroughness about Grubenmann's descriptive work, from his combining the threefold method of field-observation, microscopic examination, and chemical analysis, which is most satisfactory. The pity is that we cannot say as much for the logical soundness of his conclusions, and their bearing upon questions of general theory.

[1] *Op. cit.* pp. 94, 95.

[2] At a previous meeting of the Society the present writer entered his protest against this assumption (Q.J.G.S., August, 1889, p. 503).

[3] See "Abstract of Proceedings of the Geological Society," No. 549.

[4] That paper having been now (May 19) published, this is found to be so.

[5] "*Ueber die Gesteine der sedimentären Mulde von Airolo*," by Dr. Ulrich Grubenmann (Frauenfeld, J. Huber, 1888). I have to thank Dr. Heim for drawing my attention to this, and Dr. Grubenmann for his prompt courtesy in sending me a copy; and I offer beforehand most ample apologies to the latter, if anything in this paper may appear to him at all discourteous (etwas unhöflich).

Dr. Grubenmann works out a section in the Val Canaria (a gorge-like valley cut into the north slope of the Val Bedretto and across the main strike of the beds) on the south flank of the great Gotthard *massif.* Of this the following may be taken as an outline (the numbers denoting the ascending orders of the rocks on the mountain-flank) :—

THE VAL-CANARIA SECTION (AFTER GRUBENMANN).

7. *The Uppermost Zone of 2-mica Schists* : containing below whitish and green mica-scales, dark green biotite, increasing in the upper part until the proportions of white and dark mica become nearly equal. From this point the section passes upwards into the "amphibole- and garnet-bearing schists of the southern schist- and gneiss-zone of the Gotthard massif." In addition to quartz and calcite, microscopic examination shows them to be tolerably rich in small black mineral particles (magnetite ?), along with pyrites, hæmatite, and (sparingly) rutile. Tourmaline and zircon occur as accessory minerals (thickness ?)

6. *The Upper Zone of Gypsum, Rauchwacke, and Dolomite* : exposed in a wild gorge difficult of access (previously described by von Fritsch), but furnishing, in the insoluble residues after prolonged treatment with acids, margarite, biotite, quartz (in grains), tourmalines, rutiles, and zircons (thickness ?)

5. *The Second Zone of 2-mica Schists* (*containing disthene*) : comprising—

(*a.*) Dark-grey, coarse, stratified calc-mica-schist = 4 metres.

(*b.*) Calcareous and ferruginous quartzite (thickness ?)

(*c.*) A 2-mica schist (very feebly stratified), of grey colour and pearly lustre, apparently much slickensided (as of a 'shear-zone'), containing, besides the two micas, rutiles, tourmalines, quartz, calcite (sometimes as a pseudomorph after zoisite), an opaque black mineral (with limonitic covering of the grains), earthy clay material = $1\frac{1}{2}$ metres.

4. *The Kalkglimmerschiefer*[1] (*calc-mica-schist*) : a clear-grey argillaceous schistose limestone, with quartz grains, with light and green mica-scales on the foliation-planes and a talcose mineral adhering to the quartz-grains, interlaminated with feeble layers of a micaceous quartzite (half-schistose, half-granular), and of strongly ferruginous quartzite, terminating upwards in a bed of marble ($1\frac{1}{2}$ metres) = 300 metres.

3. *Garnet-bearing Schists* (*Thonglimmerschiefer*) : interstratified with quartzite, and falling into three principal groups :—

(*a.*) An upper group of dark grey schists (4 metres).

(*b.*) A grey brown granular quartzite with included mica, 'opaque Erzmassen,' pyrite, and amorphous limonite (10 metres).

(*c.*) A lower group of brown highly lustrous schists (1 metre).

The schists contain *garnets* (often greatly deformed by pressure), two micas (probably margarite and biotite), quartz particles, tourmalines, rutiles, and zoisite.

[1] 'Calcitglimmerschiefer' of Kalkowsky, *El. der Lith.* p. 199.

2. *The first (lowest) zone of 2-mica Schists*: grey-green to dark-green, becoming in places talcose and chloritic, very lustrous, containing, here and there, in addition to the two micas, lamellæ of disthene, also quartz-veins accompanied with calcite and kyanite: the single bands of schist not generally exceeding 5 cm. (2 in.) in thickness. Tourmalines, rutiles, zircons, zoisite, and magnetite are met with in these schists. (2 metres.)

1. *The lower zone of gypsum, rauchwacke, and dolomite*: in the gypsum occur quartz, pyrite, mica, talc, tourmaline, disthene, and a few zircons; in the dolomite, fragments of glassy quartz and calcite.

So far as the detailed descriptive work of Dr. Grubenmann goes, it is simply admirable; it is in the interpretation of the facts, as pointing in the direction of a general theory of 'dynamo-metamorphism,' that we feel compelled to part company with the author, and that for the following reasons:—

(1.) The assumption [1] that these rocks all belong to one and the same complex (Schichtenreihe) seems to be quite arbitrary, since in such a highly disturbed and deformed district as this [2] their present juxtaposition may be (and probably is) merely accidental.

(2.) Although the garnet-bearing schists of the Val Canaria have been well worked out, the author, in identifying them with the altered rocks (containing Belemnites) on the Nufenen and Gries Pass to the west, and of Fontana to the east, has fallen into a fatal error, from not testing the spurious knotty structures in the limestones, which in the pre-microscopic days of petrology were described as *garnets*. On Prof. Bonney's closer scrutiny of them this identification breaks hopelessly down. These knotty structures are found to belong to a very low order indeed of silicates, and are admittedly not garnets at all. There remains, therefore, no evidence that these garnetiferous 'schists' are of Jurassic age.[3]

(3.) If it be admitted that the dolomites, rauchwacke and gypsum are of Triassic age, this tells us nothing about the age of the schists with which they are in accidental juxtaposition; since by Dr. Grubenmann's own showing the insoluble residues of the gypsum contain minerals furnished by the weathering of the schists. Whatever therefore the age of the schists, they must be certainly much older than the gypsum. But the examination of the district by Dr. Bonney and Mr. Eccles has brought to light even more cogent evidence than this; for they find that the dolomite is frequently brecciated, and that the included fragments are derived from these very schists (with their characters well preserved), which are supposed to be younger than they. It is somewhat strange that such evidence has been overlooked, or ignored by Dr. Grubenmann in compiling his memoir.

(4.) In the assumption that certain markings in the calc-mica-schists in Val Piora, observed by Escher v. d. Linth many years ago,

[1] *Ibid.* p. 3.

[2] See published sections of the Gotthard Tunnel by Dr. Stapff; Prestwich, *Geology*, vol. i. p. 304, section i.

[3] See Grubenmann, *Ibid.* p. 17.

were "indeterminable (unbestimmbare) but undoubted (unzweifelhafte) organic remains,"[1] the author appears to have been leaning upon the 'broken reed' of mere *macroscopic* observation. This also gives way on a closer microscopic examination, as Prof. Bonney has not much difficulty in showing.

(5.) We have no right to assume, as the author does,[2] that the calc-mica-schists are rocks "which were first deposited at the bottom of the sea as limestones by the agency of organisms (durch Vermittelung von Organismen)." The present writer has shown elsewhere[3] that such assumptions are unnecessary and highly improbable for the crystalline marbles, calc-schists, and the quartzites of the oldest series of rocks. They can be accounted for in a very different way. A stratigraphical difficulty which such an assumption raises was pointed out by Mr. Eccles in the discussion of Prof. Bonney's paper; a difficulty which the present writer's own observations in the Alps enable him thoroughly to appreciate.

(6.) The inconstant relation of the dolomite, etc., to the schists and gneiss of that region of the Alps, and the extremely fresh and unaltered condition of the dolomite deprives it of all value as evidence of the age of the schists in juxtaposition with which it is accidentally found in the Val Canaria section.

(7.) In face of the evidence now to hand, it is impossible to recognize such a succession as is implied in the following proposition:[4]—"It is scarcely far from the truth, if in the original area of the sedimentary trough (Mulde), the anhydrite and gypsum is regarded as the deeper or older, and the argillaceous limestones as the upper or younger portion."

And a further difficulty arises when we attempt to plot out the section as a 'Doppelmulde' or double infold with a central anticlinal,[5] since there is no apparent symmetry between the two synclinals which are supposed to have entrapped the two dolomite groups of rocks. Moreover, the occurrence of the 2-mica schists (zone 7 of Dr. Grubenmann's section) outside the supposed Doppelmulde is strong evidence against the younger age of the same schists as they occur in zones 2 and 5.

(8, lastly.) The suggestion[6] that, "in those zones where the dolomites and argillaceous limestones are mashed into one another, the molecules in contact might, under enormous pressure, form margarite and meroxene more abundantly and produce the 2-mica schists," is seen to be worthless, from the fact that, while the 2-mica schists occur *three* times in the section, it is only in *one* instance (zone 5) that they occur between the dolomite and the supposed *quondam* limestones. And the further suggestion[7] that the garnets may have been fabricated by the combining together (Zusammenscharung) of molecules of silicates of lime and alumina is still more improbable. Even if the schists could be shown to be

[1] *Ibid.* p. 19.
[2] *Ibid.* pp. 24, 25.
[3] *Chemical and Physical Studies*, etc., pp. 7–13.
[4] Grubenmann, *Ibid.* p. 25.
[5] *Ibid.* p. 25.
[6] *Ibid.* p. 26.
[7] *Ibid.* p. 26.

of Mesozoic age (a position very far from established), a much more rational account could be given of the garnets, etc., as derived (allothigenous) minerals.[1]

The case seems to break down hopelessly, and with it this last desperate sally of the upholders of the extreme orthodox doctrine of the followers of Hutton and of his still more illustrious exponent of our own time. Science truly hath its marvels; and marvellous it is to see this nineteenth century drawing towards its close, while distinguished English geologists are 'dealing blows in the air' in defence of their pet doctrine of 'uniformitarianism,' first propounded by a most worthy and illustrious man, who lived and died when modern chemistry was as yet in its infancy, when spectrum analysis as applied to cosmical physics was not even dreamt of, when thermal chemistry was unknown, and men like Joule had not done their work and written their names on the muster-roll of Fame.

Supplementary Note (May 1st).

A great deal has been made of late in some quarters of the facts described by Dr. Lawson (of the Canadian Survey) in his paper[2] published by the International Congress of London in 1888. It has been proclaimed to the world that these afford evidence of an *igneous* origin (igneous in the plutonic sense) of the Laurentian gneisses. And yet, strange to say, they do not perceive that this is (if not an utter capitulation) a surrender of the greater half of the field by the metamorphic school. They are recognized in fact as being crystallized portions of the original magma, which was once subjacent to the earlier and thinner crust (the schists). I do not mean to say that this is admitted in so many words; but substantially it is admitted. I saw this very plainly in September, 1888. I communicated my ideas to Dr. Lawson in conversation; and in a footnote to page 68 of my "Chemical and Physical Studies," 1889, I gave this as a direct deduction from the principles of metataxis contended for in that work. I pointed out that, "As the outer zone of the lithosphere solidified through the dissipation of energy by radiation, the tidal movements still continuing, huge masses (even 'regional' masses) of the solidified outer 'crust' would *slide over the viscous magma beneath*, as the strain produced by tidal movements in the latter caused huge fractures here and there in the crust. As the magma grew more and more viscous, it is certain that under such circumstances huge fragments of the thin crust would be torn away, imbedded in the magma, and transferred in some cases to considerable distances. This seems to be the most natural explanation of the striking facts observed by Lawson in the Laurentian gneiss, and described by him in his Essay."

The facts referred to are set forth in much fuller detail in the Official Report since published, which is a very fine piece of work, as I know, from the copy which Dr. Lawson has been good enough to send me. Since the publication of that Report, Dr. Lawson has

[1] See *Chemical and Physical Studies*, etc., Appendix II. note T.

[2] Vide *Etudes sur les Schists Crystallins*, pp. 66–88.

seen his way to the adoption of what is substantially the explanation offered by myself. In a paper read before the Geological Society of America[1] (dated March, 1890), he says, in speaking of the *Significance of the Relationship* [of the gneiss-series and the schist-series]:—"Bearing in mind the essential distinctions which exist between the rock-formations of the Ontarian[2] and Laurentian systems, both as to their lithological character and their mode of occurrence, and remembering also their relative geographical distribution,[3] the relationship which obtains between the two systems leads clearly and unavoidably to this conclusion, viz. that the formations of the Ontarian system at one time rested, as a volume of hard rocks, upon a magma which subsequently crystallized as the Laurentian granite-gneiss; so that the present line of demarcation between the two systems must be regarded as representing the trace of what was once a plane of contact between the thin crust and the magma upon which it floated.

"This conclusion affords a conception of the Archæan which is ideal in its simplicity, and which gives us the key to the ravelling of the mystery in which the subject has been involved. The fact that the crust, which constitutes what we now call the Ontarian, was crumpled while it floated on the magma; the fact that its lower portions were shattered by disturbance, so that the magma penetrated the fissures and inclosed detached fragments; the fact that there were currents in the magma which arranged the inclusions in streams and so produced the foliation of the gneiss; the fact of contact-metamorphism;—all these are incidental and concomitant circumstances of the great essential condition of a crust resting on a magma."

[See a most excellent Review of Dr. Andrew C. Lawson's Memoir on the Geology of the Rainy Lake Region (being Part F, of the Annual Report of the Geological and Natural History Survey of Canada for 1887), in the GEOLOGICAL MAGAZINE for January, 1890, Decade III. Vol. VII. pp. 36–39.—EDIT. GEOL. MAG.]

V.—PHYSIOGRAPHY OF THE LOWER TRIAS.

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

FREE discussion is a valuable aid to research when entered upon in a proper spirit. I am glad to see the contribution of Mr. Jukes-Browne to this subject, together with the letter from Prof. Bonney, in the May Number of the GEOLOGICAL MAGAZINE.

Having put forward a theory of the origin of the Lower Trias, I cannot object to its being tested in every way; so in this spirit I will proceed to answer as best I can the criticisms which it has called forth.

It appears to me that Mr. Jukes-Browne has scarcely grasped the

[1] See "Bulletin of the Geol. Soc. of Am." vol. i. pp. 175–194.

[2] An inclusive term now proposed for the Upper Archæan [= Coutchiking and Keewatin series.]

[3] Lawson estimates the Upper Archæan as easily 9 miles in thickness; but they are small in extent compared with the gneiss series.

significance of the examples of tidal action which I gave in my last paper.[1] The quotation there given respecting the "remarkable ditch" scooped out by the tide opposite Wigtonshire is in Captain Beechey's own words. That very efficient and scientific officer had no theory to uphold; but the cause and effect were so clear to him that he speaks without hesitation. I had marked years ago (1873) on a large Admiralty Chart the stream tide lines taken from Captain Beechey's survey, and this "remarkable ditch" is in exact parallelism to them. There is also another striking example of excavation by the tide at the northern entrance to the Irish Sea confirmatory of this view. Opposite and north of Rathlin Island there is a "deep" in which the greatest sounding is 133 fathoms = 798 feet, the surrounding sea-bottom being from 60 to 80 fathoms only. A portion of the bottom of this depression at a depth of 105 fathoms or 630 feet is rock, while the surrounding soundings in the shallower water are sand and shells, a clear proof that the "deep" has been excavated.

Hurd "deep" opposite the "Casquets" in the English Channel is another example of a long narrow channel where at a depth of 73 fathoms the bottom is rock, and at 95 fathoms sand and stones, the surrounding bottom being from 30 to 40 fathoms only. The form of the bottom of the sea below the depth at which wind waves act is the resultant of the rub of the tide on the bottom at one place and deposition of the eroded material at another.

According to a letter received by me from Sir G. B. Airy, the Astronomer Royal in 1873, the difference between the surface and bottom velocities *is the measure of the work done by the tide on the bottom.*

I think I may be excused repeating these facts and principles, as I regret to say that the subject has hitherto received little attention from geologists.

Mr. Arthur R. Hunt (Geol. Mag. April, 1890, pp. 191–2) goes so far as to assert that the tides in the English Channel, taking it as a test case, have no effect on the bottom at all, "that they are incapable by their own unassisted efforts of raising the sand," and if I understood him aright, bases his opinion upon the existence of molluscs in the channel which could not live did the tides in any way disturb the sands! Curiously enough, I read in *Nature* (April 19th, p. 569) shortly afterwards that Major Reinhold, in a paper on the botanical condition of the German Ocean read at a meeting of the Natural History Society of Kiel, states that, according to researches recently made, the Eastern part is almost wholly bare of vegetation. "This is believed to be owing to the strong tidal currents which so disturb the sea bottom as to prevent the germs and spores of marine plants from settling."

The Admiralty Chart of the English Channel shows a bottom in many places composed of stones or gravel, or sand, stones and gravel, at depths below the influence of wind waves; so, if we accept

[1] Geol. Mag. April, 1890.

Mr. Hunt's views, we must also be prepared to believe that the bottom is now exactly as it was when first submerged, an opinion in which he will not get many geologists to support him.

Though not a naturalist, I happen to live on a coast in which the combined action of the wind and tides are continually disturbing the sand banks and the channels and the sandy shore, and thousands of molluscs—I might almost say millions—are dug up during a storm and cast on the shore; yet sufficient remain to keep up the "breed" so to say.

If molluscs can live under these conditions in the Estuary of the Mersey, why not in the English Channel? I may be therefore excused for thinking that their existence in the English Channel proves nothing respecting the tides either one way or the other.[1]

In the Mersey, between Liverpool and Birkenhead, we have a striking instance of the excavating power of the tide. At one point over the Mersey Tunnel, as proved by divers, the rock was bare, with great boulders lying upon it derived from the destruction of the Boulder-clay. It would be wearisome for me to go on multiplying these instances; suffice it to say that the form of the Mersey bottom is evidently due to tidal rub.

I have thought it necessary to detail these instances of the effects of tidal action, as, if the tides are physically incapable of producing the effect I attribute to them, viz. the current bedding of sandstones and the rolling of pebbles as seen in our typical Bunter, my theory is invalid.

As regards Prof. Bonney's criticism, from the known attention he has given to this subject his views no doubt deserve the greatest consideration. I am, however, compelled to say that I fail to see why the Lancashire Bunter, which is of great thickness (proved to 1200 feet), and occupies a large area, should be looked upon as anomalous, and our attention be restricted to conglomerate beds of 60 feet in thickness. These beds occur in the Midland Counties, and may have been shore deposits, as suggested by Mr. Jukes-Browne. I expressly said in my last communication that my theory does not exclude shore action. How can there have been seas and embayments without shores?

There are, however, no evidences of littoral deposit in any of the Bunter of Lancashire and Cheshire that I have seen; and this it was partly the province of my theory to explain.

It seems, however, I am expected to sketch out the physical geography of the Triassic period, and localize the communications of the Triassic Sea with the Atlantic Ocean. Surely this is making a

[1] Mr. Hunt asks, "Would Mr. Mellard Reade give his reasons for believing that waves ever cause surface particles in deep water to move in a vertical circle, or an ellipse, not very different from one having the longer axis vertical?" If Mr. Hunt will watch a cork floating in water on which wind waves are generated, he will, I think, see that the vertical oscillatory movement of the cork is as great as or greater than the horizontal. The composition of the two movements will give either a circle or an ellipse. This is no discovery of Mr. Reade's, but a fact known to every physicist.

considerable demand upon me, and in the slang of the day is what is called "a big order." I am not even prepared to say that there was then an Atlantic Ocean in the sense that we understand it now.

The possibilities of the physical geography of the period are so great that I see no difficulty in the origin of a tidal wave in an open ocean, and its propagation through the embayments or channels in which I suggest the British Trias was laid down. Even in the North of Ireland, in the neighbourhood of Carrickfergus on Belfast Lough, the Trias is estimated at 2000 feet thick.[1] On the other hand, on Slieve-Gallion-Carn, west of Lough Neagh, the Keuper is found at an altitude of 1200 feet above the level of the sea.[2]

How can we in view of such facts as these aver that the English Trias was laid down in a basin with shallow entrances? On the other hand, as I pointed out in my original paper read before the British Association (GEOL. MAG. December, 1889), there are the possibilities of the extension of the Trias to the eastward under the newer rocks.

We are dealing only with *remnants*; we have not materials now to reconstruct the physical geography of the past with any degree of accuracy; but we know enough of the manner of occurrence and extension of the Trias, of which the Bunter is one phase, to make it difficult, for me at all events, to see how its distribution can be explained by river action.

I devoted a fortnight last summer to an examination of the Trias of the Vale of Clwyd. At none of the sections I visited, and I saw most, could I detect the presence of local materials unless it were some of the marly material binding the grains. There were no pebbles, either quartzite or otherwise, in the sandstones which are considered to be Lower Bunter, but much persistent current bedding. This *crux* is explained by tidal action, which in a *cul-de-sac* would have less force than in the channel (now occupied by the peninsula of Wirral) between the mountains of Flintshire and the Carboniferous hills of Lancashire, forming a communication between the Triassic area covered by the Irish Sea and that of the Midlands. It is on these stream lines that the greatest development of the pebbles of the Bunter of Lancashire and Cheshire occur.

Prof. Bonney naturally lays great stress upon his identification of some of the pebbles of the Trias with those of the Highland rocks.

While giving due weight to his opinion on this point, such identifications can scarcely be put in the category of absolute certainties.

There is also another explanation of their presence volunteered by Mr. Jukes-Browne, who suggests that they may be only indirectly derivative from the Western Highlands of Scotland, even if that were their original home. It is the increase in the number of and size of the pebbles towards the Midland Counties that makes it difficult to conceive that they came from the North.

[1] Kinahan's Manual of the Geology of Ireland, p. 138.
[2] *Ibid.* p. 141.

VI.—Note on the Occurrence of the Tunny (*Thynnus thynnus*) in the Cromer "Forest Bed."

By E. T. Newton, F.G.S., F.Z.S.

Mr. R. Storms has recently described (Bull. Soc. Belge Géol. vol. iii. p. 163, 1889) the vertebræ of a large Tunny from the Antwerp Crag, which he has named *Thynnus Scaldesii*, and Mr. A. Smith Woodward, in the April number of the Annals and Magazine of Natural History, records the same species from the Coralline Crag of Suffolk; it is especially interesting, therefore, to be able at this time to notice the occurrence of the common Tunny (*T. thynnus*) in the Cromer "Forest Bed."

Early in the present year, Mr. A. Savin, of Cromer, found in the "Forest Bed" of East Runton a large Teleostean fish-vertebra, which he sent to me for identification, and which agreed so closely in all its characters with the nineteenth vertebra of the large Tunny in the Museum of the Royal College of Surgeons, that I had no hesitation in referring it to the same species. This vertebra has lost all its processes, but the centrum now measures 43 mm. long, 53 mm. wide, and 45 mm. high; it is deeply biconcave and somewhat depressed; it is further characterized by a single large longitudinal bar on each side, which thickens anteriorly and posteriorly, a roughened space towards its front part indicating the point of attachment of the rib. Above and below the bar is a deep fossa.

The nineteenth vertebra of the Tunny in the College of Surgeons measures 49·5 mm. long, and 60·5 mm. wide, a proportion of length to width almost exactly that of the Forest Bed specimen.

It was intended to reserve the notice of this species for a forthcoming memoir of the Geological Survey, but the publication of Mr. Smith Woodward's account of the Coralline Crag *T. Scaldesiensis* seemed a fitting opportunity to make known the occurrence of the recent species in the uppermost beds of the English Pliocene. After a re-examination and comparison of the Forest Bed vertebra with the recent form, and also of the Antwerp and Coralline Crag specimens, I am quite of opinion that the Crag fossils are specifically distinct from the living *Thynnus thynnus*, but am confirmed in my identification of the "Forest Bed" vertebra with the latter species.

VII.—Notes on the Probable Origin of Some Slates.

By W. Maynard Hutchings.

Mr. Sorby, in his Address as President of the Royal Microscopical Society in 1877, dwelt very forcibly on the interest and value attaching to researches into the original nature of the materials composing sedimentary deposits, and stated that, so far as he was aware, but little had been done in this direction by means of the microscope (Monthly Microscop. Journal, vol. xvii.).

Since Mr. Sorby delivered that address much has been done in this direction, both by workers in this country and on the Continent, and more especially with regard to slates and allied rocks. But much still remains to be done before we are able, in a satisfactory manner, to read in the slates, shales, sandstones, etc., the record of their origin and subsequent development; and so, as Mr. Sorby says, to "as it were, sometimes trace back the genealogy of our globe a generation or more earlier than by other means."

The following notes, resulting from considerable study of some of the materials in question, have only a limited bearing on a limited portion of this very wide subject, but are offered in the hope that they may not be wholly wanting in value as a contribution towards explaining some of the questions involved.

During the examination of a series of sections of slates (roofing-slates and closely similar material from Wales and Cornwall), two or three special points of interest arose which led me to wish to study in detail some more recent deposits, which might show less advanced stages of the chemical and morphological changes which have taken place in the original sediments. At the same time I specially wished to have deposits as to which one could be quite sure that they were derived from the waste of granite areas. Materials answering these requirements are to hand in the Carboniferous formation, and especially in the Coal-measures, the sandstones, shales, etc., of which are, I think, usually considered to have been derived from granites, and this has certainly been the case with some of them that I have worked upon.

Some of the observations made appear to have sufficient bearing on the eventual development of certain slates to warrant a rather detailed account of them.

I will select for description the materials of a bed exposed in the cliffs near the village of Seaton, a few miles north of Newcastle-on-Tyne. This bed, several feet thick, is composed mainly of indurated clay of various degrees of fineness. The finest does not show to eye or pocket-lens a flake of mica or a grain of any sort of sand, and yields when ground with water a clay of the highest degree of smoothness and plasticity. Bands of this alternate with others in which more or less mica is seen with the naked eye, and which, while still fully plastic with water, contain a good deal of gritty sand. These again pass into still coarser layers, while here and there are bands, some inches thick, of fine-grained, laminated, soft micaceous sandstone. There are also, at places, very thin bands of clay-ironstone. Lamination is not so well marked in the finest clay as in the coarser and harder bands, where it is highly developed; such bands verging in nature towards soft shales.

The greater part of the bed in question is really a more or less coarse-grained "fire-clay," similar in all respects to the fire-clays worked on a large scale in the district, differing only in the mode of occurrence, the regular beds, with the seams of coal, being mostly more or less unstratified and irregular.

Above the bed just described is one of several feet of micaceous sandstone, followed by a series of several feet of clays, soft shales, and sandstones, with a very thin seam of coal; and finally a considerable thickness of hard compact sandstone. The whole has undergone some considerable disturbance, having been thrown into folds, while at several points the clay beds are faulted and puckered.

Some of the coarser, harder, more micaceous deposit was taken out and subjected to detailed examination. Sections were prepared of it, and its component minerals were also separated, as far as practicable with materials of this nature, by levigation and by use of Sonstadt's solution.

It is of the greatest importance to always, whenever possible, study clays, soft shales, etc., mounted as continuous sections as well as in crushed form in water and balsam. It is only by so doing that the relationship of the various constituents to each other can be properly observed. Even with quite soft clays it is practicable to prepare sections; or perhaps the word "section" hardly applies in such cases, and one might call it a continuous layer or film.

The material, well dried but of course never so heated as to lose any of its *combined* water, may be cut into pieces of suitable size with a knife, levelled off on a hard rough surface (good emery-cloth does excellently), brushed clear of dust and smoothed, without water, on a ground-glass plate; then warmed again and cemented in the usual way to a slide. The piece, which must be thick for the foregoing operations, is now cut down with a knife, rubbed down pretty thin on emery-cloth and finished by very careful work, with water only, on a glass plate.

Exceedingly thin films may be got in this way, but the outer edges, or the thinnest margins of holes that may have been worn here and there, will be found of most value for the examination of fine-grained clays under high powers.

Sections of the material in question show that it is made up mainly of mica, both muscovite and biotite, with grains of quartz and felspar, and that zircons and other accessory minerals are present.

A quantity was crushed to powder and suspended in a solution of 3·1 sp.g. The minerals which fell out were zircons, numerous and of rather large size, garnets in angular colourless fragments, crystals and fragments of rutile of the usual sort found in sands. Anatase was seen as one or two small pyramidal crystals of bluish colour, and also several beautifully perfect thin tabular crystals, pale yellow to colourless. The largest observed was $\frac{1}{350}$ inch in diameter, others being $\frac{1}{500}$ and less. They are perfectly sharp and unworn in any way, and are doubtless formed *in situ* in the deposit, as has been demonstrated of similar crystals by Thürach ("Ueber das Vorkommen mikroskopischer Zircone und Titan-Mineralien in den Gesteinen," Würzburg, 1884). There is also a good deal of tourmaline in crystals and angular fragments, and one or two grains of sphene. Further, numerous colourless, transparent, tabular crystals of rhombic shape were observed. The long diameters of the largest crystals measured were $\frac{1}{250}$ inch, but many are much smaller. The acute angle of the rhombs is 78°. An obtuse bisectrix emerges on the face of the tablets and the bi-refraction is positive. These crystals thus correspond in all respects with one of the forms of baryte (I think known as the "chisel-shaped" crystal), and taken in conjunction with the high specific gravity they may be safely set down as being that mineral. Barium sulphate is frequently found as a deposit in colliery waters, and doubtless these crystals were formed from the solutions circulating in the sediment.

The quartz-grains average from $\frac{2}{1000}$ to $\frac{3}{1000}$ inch in diameter; they are in all respects of the nature of granite-quartz and are both angular and more or less rounded. Some of them I consider are *corroded*, but I confess I do not find myself able to make quite sure of this, though Mr. Sorby says that chemically corroded quartz is readily distinguished from simply worn grains.

The numerous felspar-grains are more rounded than the quartz. Many are pretty fresh; but unless cleavages or other special marks facilitate recognition, it is safer not to set down anything as felspar which does not distinguish itself from quartz by its optic figure in convergent polarized light. One or two grains of plagioclase were observed giving nearly straight extinctions,—presumably oligoclase, and one or two grains of microcline.

Mica, both muscovite and biotite, is abundant, the biotite being in excess over muscovite. The largest flakes measure about $\frac{1}{100}$ inch in longest diameter; thus one biotite flake measured $\frac{1}{100}$ by $\frac{1}{250}$ inch, and there are all sizes down to very small indeed. The muscovite is in all the distinct separate flakes seen in the sections, or isolated, in all ways fresh and normal, and shows no inclosures of any sort beyond those to be seen in granite, *i.e.* small zircons, etc.

Of the biotite the greater part is more or less altered, but the still fresh flakes show it to be optically and otherwise a quite normal granitic type.

It seems thus quite clear that in this deposit we have the waste of a granite with two micas, and I am not able to detect any grains of any sort to give rise to the inference that other rocks, older slates for instance, took part in supplying the material.

The alteration taking place in the biotite is of much interest for reasons already alluded to. Contrary to what would be expected, alteration to chlorite does not take place, or if it does, it is only to a very slight extent. A very small number of greenish flakes may be observed, but they are not chlorite. Such green flakes are seen in granites and other rocks, and may mark an early stage of the alteration of biotite to chlorite, though I believe they are in some cases looked upon as an original greenish mica. They certainly are not chlorite yet, and I have not detected any of that substance in these deposits.

The alteration which has taken place so extensively shows itself in a bleaching of the biotite and the development in it, in large quantity, of a substance of high refraction and very high double-refraction. It appears to be mainly epidote, which mineral is well known to be frequently produced during the alteration of biotite. It forms in clusters of small round or more or less oval granules, in irregular plates and flattened grains, and sometimes in plates of more definite outline, among which a few may be found as large as $\frac{1}{1000}$ inch in diameter, showing the form sometimes of four-sided rhombs; sometimes of six-sided figures by the addition of two very small faces truncating the acute angles of the rhombs. These forms correspond with the clino-pinacoidal section of epidote crystals, with which also the extinctions fully agree. Many of these aggregates of small thin plates, all parallel to the cleavage of the mica, often more or less overlapping one another, present a peculiar characteristic appearance I have not seen in epidote under other conditions.

Thürach (*op. cit.*) mentions a mineral as occurring among the débris of several of the rocks so exhaustively examined by him, which he describes as "small, light-yellow, feebly pleochroic, strongly bi-refractive crystals or rounded grains of rhombic or hexagonal form, mostly tabular and clear, often showing cracks, with a perfect cleavage parallel to the base." He quotes Klemm as having looked on these as sphene; says he himself also considered them to be that mineral, but now looks on them as "potash-mica," though, as he admits, they would not be readily recognized as such. I think there is not much doubt that what he mentions is epidote in the thin superposed tablets, resulting from biotite as just described.

Here and there, but very rarely, a few crystals of rutile are seen in the altering mica. I am of opinion that rutile in granules is also formed with the granular epidote, though it is not possible to make sure of it. I have seen in some Cornish and other altered sedimentary rocks just such clusters of rounded grains of rutile, with short and comparatively blunt *crystals* of that mineral under conditions which lead me to the belief that under the influence of dynamic metamorphism the rounded grains are capable of taking definite crystal form.

The bleaching which accompanies this development of epidote in the biotite is attended also by a rapid loss of the optic properties of the mineral,—its strong bi-refraction and its figure in convergent polarized light. Much of it, in large flakes, becomes so colourless as easily to be taken for muscovite when lying flat, till tested optically.

The substance of the bleached biotite seems to waste away and be entirely removed from its original position. Flakes may be seen in all stages of this removal, getting more and more indistinct, the clusters of grains and plates of epidote remaining until finally we see, throughout a section, many of such clusters without any of the original surrounding mica.

As regards the structure and arrangement of this soft shale as a whole, the quartz and felspar grains are pretty uniformly dispersed and the original mica lies mostly flat in the plane of bedding and lamination, with, however, a sufficiently large proportion lying inclined, to justify the conclusion that the deposit took place in very quiet water and was not appreciably levelled and sorted by currents. There is a good deal of fragmentary organic matter present throughout, and a good deal of limonite, diffused and in patches, which doubtless to some extent represents a part of the iron originally in combination in the biotite.

In addition to the grains of quartz and felspar and the more pronounced flakes of muscovite and variously altered biotite, as above described, the sections show the presence of another sort of component which lies in among these former, and in some parts more or less surrounds them, after the manner of a sort of ground-mass, or "paste," so to speak. It contains much that is quite indeterminable,—indistinct granular matter with specks and microlites of various sorts, and with all this a great deal of a fine, micaceous, dimly depolarizing material. In among this may be seen larger flakes of a mica which differs distinctly, in many ways, from any of the original clastic mineral.

All this is better studied in sections from a much finer-grained portion of the deposit, intermediate between that described above and the finest clay-bands. In such sections all the appearances above noted are seen, but the "paste" bears a much larger proportion to the other constituents. It doubtless represents the finest portion of the original deposit, the finest mud or silt, made up of "kaoline," the minutest powder of felspar and quartz, and the smallest flakes and shreds of mica. Throughout this "paste" (I will use the word here for convenience, though not well suited) immense numbers of minute rutile crystals are seen, the larger ones transparent, many twinned, vividly depolarizing; the smaller ones as dark, hair-like needles. Also a good many very thin small flakes of micaceous ilmenite, transparent with the characteristic shade of brown, and many very small perfect crystals of tourmaline.

There is a considerable amount of the mica[1] above referred to, evidently secondary, formed *in situ*. It is possible to trace the distinctly clastic mica, more especially the muscovite, down to very minute fragments indeed (correspondingly small biotite is not seen, as such finely divided parts are soon wholly obliterated by alteration). Then comes a point where it is often not possible to form any judgment as to whether what is seen is original or secondary. But there is much where no such doubt is called for. Flakes of various sizes, but all small, are seen, colourless or more usually pale greenish or yellowish. The larger ones blend away at their edges with the surrounding fine material in a manner which none of the original flakes of muscovite of similar size do, and they are all more or less full of the minute rutile crystals, not a trace of which occurs in any of the original muscovite. Here and there, though rarely, flakes may be got which are of sufficient size and thickness to test in convergent light. The optic axial angle is usually approximately the same as that of the original muscovite present, but in some cases it is noticeably less.

This newly-formed mica is not uniformly diffused as to its larger flakes, but the finer-grained paste in which it lies, and of which it

[1] It should be understood that by the use of the word *mica* there is no intention to infer that anything sufficiently definite is ascertainable about the substance in question to enable it to be certainly referred to any recognized variety of mica. The word is used only to express the fact that the observable characters of the mineral, including such of its optic properties as can be ascertained, bring it into close resemblance to some of our known micas.

forms a part, is everywhere seen when the sections are thin enough; and many grains of quartz and felspar, detached from the mass and separately mounted, retain a skin or coating of this paste with its secondary mica and the small rutiles, the impression produced being that the surfaces of some such grains are really attacked, as it were, by the paste and beginning to blend with it, not simply mechanically adhering.

Turning now to sections of the most fine-textured of all the bands, the smoothest finest-grained clay, it is seen that the still recognizable original minerals play a comparatively small part, the main component being the same material which is the paste in the coarser-grained beds. Biotite has wholly disappeared; original muscovite is still present throughout, though nearly all very small. But little epidote is seen; all the various indeterminable matter as before, with an increase in the amount of indistinct granular matter usually spoken of as kaoline. The entire mass is crammed with small rutile crystals and microlites, and shows all over it more or less of the small flakes of secondary mica with the inclosures of rutile, etc.

Looking, finally, at the other extreme,—the coarser bands of micaceous sandstone before mentioned, and the thicker beds of the same overlying,—these are seen to be composed of quartz, felspar and two micas as before, the biotite having been in excess. Owing probably to the greater percolation of water through this coarser material, the biotite has suffered more alteration, even in the largest flakes, than in the other bands, a larger proportion of it being wholly removed, leaving clusters of grains and plates of epidote to mark its former position. Very little fine silt of any kind seems to have been deposited during the conditions which obtained whilst these coarser materials were being laid down. There is hardly any of the rutiliferous paste to be detected anywhere, nor secondary mica; indeed, no very small mica of any kind.

Materials such as I have attempted to describe above are obtainable all over the district in natural exposures and from coal-pits, and always show the same things, as do also specimens from other and distant coal-fields.[1] I have several examples mounted illustrating the passage of such shales and clays, still showing much original biotite, into finer grades with no trace of that mineral remaining. All the fire-clays examined,—those being worked extensively for brick-making and others taken from beds not so worked,—all show the same composition and structure under the microscope, though varying a good deal in the relative amounts of sand, original mica and "paste"; and the part I speak of as paste again varies very much as to the proportion of it which consists of

[1] Among other material examined, I am indebted to Mr. G. H. Askew, of Aspatria, near Carlisle, for a series of specimens of the cores from a bore-hole put down at that place to prove the coal-seams. This series of clays, shales, and micaceous sandstones, extending to 800 feet in depth, proves to have been all derived, like the beds in the Newcastle coal-field, from the waste of a granite with two micas; and the changes undergone by the materials of the deposits have been the same.

the minutely-granular "kaoline," and of micaceous material with rutiles.

It is stated in nearly all books on the subject that clays consist mainly of hydrous silicate of alumina, and this definition is repeated in works dealing specially with fire-clays, as true of them also. Thus Percy (Metallurgy—volume on Fuel, Fire-clays, etc.), says: "All clays as they occur in nature consist essentially of *hydrous* silicate of alumina."

This definition, derived as it is mainly from the *chemical* study of clays, is certainly not universally true, and is seldom true as to fire-clays. It is, however, very much more true in a chemical sense than in a mineralogical or petrological one. Later on in the same treatise Percy, with more of his usual caution, sums up as follows: "The conclusion, which appears to be justified by the foregoing considerations, is that one definite hydrous silicate of alumina, namely kaolinite, has been found in many instances to constitute the basis of substances usually designated clay; and in the present state of our knowledge more than this cannot confidently be asserted."

As regards the presence of kaoline in clays, it appears to me that the word is often used very vaguely. We know, of course, that kaoline, a definite hydrous silicate of alumina, is formed during the decay of felspar, and we can frequently obtain it well crystallized, as in the interstices of many grits and sandstones. In this pure form, however, it rarely, if ever, reaches deposits of clays. China-clay is usually supposed to consist most largely of it; but deposits of this clay are comparatively rare and limited, and are due, probably, largely to other causes, as well as to the ordinary atmospheric weathering of granites. And even in the purest china-clay the microscope shows the presence of a very large proportion of mica and other things. Moreover, we know that the decay of orthoclase felspar does not give rise only to kaoline, but also to mica; and, as Rosenbusch points out, we are not well able to distinguish microscopically between the two processes when in progress,—processes "which are chemically very nearly related, and depend upon a partial or total replacement of potash by water with separation of $4\,SiO_2$." It is probable that decaying orthoclase yields to denudation as much very minute hydrated mica as it does kaoline. The latter, in course of transport with water, will become reduced to impalpable granules, will be thoroughly incorporated with the finest waste of other minerals, and will finally be deposited as a very complex substance.

So far as I am able to make out, the very thinnest possible films of a "fireclay" show under a good $\frac{1}{8}$ inch objective a minutely-granular substance, usually of very faint yellowish tinge, and of such extreme tenuity that in polarized light it is either quite inactive or depolarizes only just perceptibly in a faint "speckly" manner. This granular matter is, I suppose, the mixture usually spoken of as kaoline. As soon as we examine a film a little thicker, but still extremely thin, we see between crossed Nicols a more distinct depolarizing action of the granular matter itself, and also the presence of more or less numerous extremely small flakes of a micaceous mineral. In films a little thicker still, we usually soon reach a point where the action of the granular matter is obscured by the depolarization of this mica, much of which, when mounted in balsam, cannot be made out at all in ordinary light.

In most of the fireclays I have examined, the mica and other substances (quite apart from actual sand and coarser flakes of mica, etc.) much exceed the "kaoline." The plasticity of such clays seems, as has been suggested by some writers, to depend largely on the fineness of the particles; also probably on their physical nature connected with the hydration of the mica, because of all these clays it is true, as it is of more kaolinitic clays, that as soon as they are dehydrated, they are no longer plastic.

The universal presence of a notable amount of titanic acid in fireclays was announced by Riley in a paper published in 1862 (Journ. Chem. Soc. vol. xv.), in which many analyses are given, and where those who are not already aware of it may get full information as to the separation of titanic acid, and may see also how it comes that it is so often left undetermined in analyses of silicates.

It is now known, of course, that this titanic acid so universally diffused in clays shows itself to the microscope as crystallized rutile, for the most part.

I think it is now largely considered that in the more advanced shales, and in slates, we have the result not simply of consolidation of original deposits, but also of considerable chemical changes resulting in the formation of new minerals; and also that these changes sometimes partly commenced to take place at comparatively early periods after the deposits were formed.

The object of these notes has been to confirm this in some cases and also to endeavour to trace out, as far as may be, *what* is the course of such changes in a sediment of known origin and composition.

The development of so much rutile in the paste of these shales and clays is of interest, because none of the original minerals of the deposits contained it as such.

In the present state of our knowledge of the composition of these minerals we must be led, I imagine, to the conclusion that the biotite has been the source of this rutile. Biotite has often been proved by analysis to contain titanic acid in combination up to between three and four per cent. So far as I am aware, neither orthoclase nor muscovite has ever been shown to contain any of it. Minute dark hair-like inclosures in quartz of granites are sometimes spoken of as rutile, but apparently without definite proof; at other times they are called "schorl," also without proof, while sometimes they are spoken of first as one and then as the other, as by Mr. J. A. Phillips in his paper on grits and sandstones (Q.J.G.S. vol. xxxvii. 1881)—often on the same page. Granting that they are rutile, as is very probable, the amount of that mineral set free by the wear of quartz, and so introduced into a sediment, would be very minute; and the quartz of many granites is free from these inclosures.

The hornblende of some granites probably contains titanic acid, but its amount in most granites is not large, and in the deposits now specially considered no sign of that mineral is seen. The sphene present in granites is also in relatively very small amount, and its fragments in deposits scarce and irregular in diffusion. Probably *all* biotite of granites contains titanic acid, if only it were sought for in analysis. We know that in numerous cases rutile is seen in decomposing biotite, though it is apparently by no means a common observation; and biotites have been proved to contain titanic acid in rocks in which they did not show rutile during decay (*e.g.* Thürach, *op. cit.*).

That the granitic magma is titaniferous is often proved by the original sphene and rutile present. It seems as if after the separation of these the remainder of the titanic acid were absorbed in the biotite.

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

REVIEWS.

I.—The School Manual of Geology. By J. Beete Jukes, M.A., F.R.S. Fifth Edition. Edited by A. J. Jukes-Browne, B.A., F.G.S. 8vo. 418 pages; with numerous Woodcuts. (Black, Edinburgh.)

THE late Professor Jukes's motive in preparing this small Manual was to aid young students to get clear notions in both technical and philosophical Geology, and to enable grown-up amateurs to realize "a fair general notion of the scope and nature of that Science." This end and aim has been well kept in mind in all subsequent Editions of the book, with conscientious care and creditable results of advanced knowledge in the many divisions of the subject-matter. As it now stands, the School Manual treats of—I. Geological Operations now in action: first, the earth is taken as a whole, with its external features and internal condition; (2) volcanoes are next considered, and earthquakes, and rise and fall of the ground; then (3) igneous rocks and their constituent minerals; (4) rocks mechanically formed, whether on the surface of the Earth by water, ice, and wind, or in the sea, not far from coasts; (5) rocks of organic origin, whether derived from the accumulation of plants, or of animals. Thus, (1) the destruction and reproduction of strata and other rocks; (2) geological time, as deduced from a consideration of the natural processes and operations, of which these are the results and evidences; (3) the balance of power in the constant action and reaction in the various physical agencies always at work on and in the Earth's crust, are brought clearly before the reader. II. Some of the facts observable in the Crust of the Earth, such as (1) strata or rock-beds, with their lamination and stratification; (2) rock-blocks, joints, also columnar and spheroidal structure; (3) concretions; (4) inclined and bent strata; (5) faults and lodes; (6) metamorphic rocks; (7) granitic rocks; (8) mountains, hills, and valleys; (9) unconformity and overlap of strata; (10) the nature and occurrence of fossils; are briefly but distinctly noted, sometimes in detail. III. The history of the formation of the rock-groups found in the British Isles; (1) treating of geological history, time and nomenclature; (2) the Archæan or Eozoic period; (3) the Cambrian and Ordovician periods; (3–12) the Silurian, Devonian, Carboniferous, Permian or Dyassic, Triassic, Jurassic, Cretaceous, Older and Newer Tertiary, and Pleistocene systems and periods, are then taken in succession, with some of their most important fossils, in such a manner as to indicate the chief points to be remembered by the amateur, and to be further worked out by the real student.

Like the Author of this book, the Editor has had good technical experience, being engaged on the Geological Survey of Great Britain; he is also evidently a reading man, and conversant with old and new books; indeed we are glad to find him using the new (second) Edition of the Rev. O. Fisher's "Physics of the Earth's Crust," only a few months old. The aid which Mr. Jukes-Browne has received from Professor Bonney with regard to Petrology, especially Igneous and Metamorphic rocks, and from Mr. Whitaker about the Cretaceous and Tertiary formations, is gratefully acknowledged, and goes far to assure the student of the exact treatment these subjects have here received.

The names of good observers and writers are not unfrequently referred to in some parts of this "School Manual"; but few only are mentioned in connection with the palæontological chapters. If even the authorities for the species of those fossils which are figured had been given, the student would have had some clue to the palæozoology and palæophytology of the past, should he wish to carry out any investigations in Geology.

The illustrations throughout are mostly selected from those used in Professor Jukes's excellent "Students' Manual of Geology," which were nearly all original, and drawn for that book; and they still remain good and trustworthy. One very useful diagram (of "overthrust-faults") has been added at p. 161. Among the fossils, on the contrary, we should prefer to have seen the figures of "Pleistocene fossils" (given in a former edition of the "School Manual"), instead of the hideous and false portraiture of the Mammoth at page 396. The several parts of the borrowed fig. 102 require an explanation which they do not get; so also a part of fig. 80.

The plan of giving the derivation of the names of fossils, and indications of the prosodial "quantity" of their syllables, is very good, and much required now-a-days, when students of natural history are too often destitute of classical learning. The omission of some of these indications, as in *Pterinea*, *Hippopodium*, and *Goniopholis*; or misplacements, as in *Cardiŭm*; or mistakes, as in *Cuviĕri* and *Volŭta*, show the necessity of close reading for the press. Some of the explanations too would be the better for revision: thus, though of little consequence, Olĕnus was the son of Neptune and not of Jupiter; *flabellifer* is "fan-bearer," not "fan-tail"; there is no basis for the word "plant" in the etymology of "*Stigmaria*," nor of "shell" in that of *Terebratula, Producta, Goniatites, Galerites,* etc.; *comptus* means "neat" rather than "ornamented"; and *grandis* "large" rather than "magnificent." *Labyrinthodon,* and other names with a similar ending, are regarded as masculine (as indeed is *Mastodon* in this book), and not neuter; "*Cardium*" is not really "a heart"; "*coranguĭnum*" should be "snakes' (not snake's) heart,"—*coranguīnum,* snake-heart, is better; and *Ostrea* (not *Ostræa*) is correct. These and a few other such points should be attended to for the sake of illiterate beginners.

There is but little else to be found fault with:—perhaps, however, we should note the carelessness of expression at p. 41 (repeated from earlier editions), where the Esquimaux boat-poles, though they have been moved inland, still remain beneath the sea. The retention of "Plastic Clay" in place of "Woolwich and Reading Beds," as also in former editions, has evidently escaped the Editor's notice (p. 333). At page 362 the basalt of Antrim is referred to as of Miocene age, but on the previous page it is placed among the "Eocene Volcanic Rocks," being of the same age as those of Mull, which have Eocene plants interstratified with them. This discovery ought to have been credited to Mr. J. S. Gardner, as an important correction of a former notion about the existence of Miocene beds in the British Islands.

The chapters on the Palæozoic formations are much improved; but necessary succinctness has limited the subject very much. Still, Wales ought not to have had its chief Coal-field put into the South of England. The Ordovician and Cambrian are carefully distinguished from the Silurian proper, and from the Pre-Cambrian and Archæan rocks. The Cambrian *Hymenocaris,* however, ought not to be still handed down with three front spikes (p. 240), which Mr. Salter long ago did away with; and the organic standing of *Oldhamia,* having been doubted, cannot at present be dogmatically defined (p. 231).

Among the good points in this little book, we may notice that the rival theories of the formation of Coral Islands are very carefully placed before the student (pp. 97—110). We doubt, however, if Prof. Jukes would have so freely accepted Mr. Murray's views as the Editor seems to think.

The decided value and usefulness of this "School Manual" authorize us to offer the foregoing remarks on some shortcomings for the Editor's consideration,—being assured that the book is well suited to teacher and student in advancing the progress of liberal education, and therefore worthy of all the improvements that its limits will allow. Believing that the success which it has already enjoyed will continue and increase, as it well deserves, we cordially recommend this book to school-masters and their classes, as well as to students and amateurs.

II.—North American Geology and Palæontology for the Use of Amateurs, Students, and Scientists. By S. A. Miller. 8vo. pp. 664: 1194 figs. in text. (Cincinnati, Ohio, 1889.)

THIS is to all intents and purposes a third edition of the "American Palæozoic Fossils," which first appeared in 1877, and which, increased by a supplement, was re-issued in 1883. These editions however were without illustrations, and the later one comprised but half the number of pages which the present volume, weighty certainly in its mass, runs to.

The author begins his preface with the statement that "a general knowledge of Geology is probably of greater importance to the people of the United States than a like amount of information in any other department of natural science," a remark which may certainly be held capable of application to a yet wider section of the globe.

Turning to the work, however, it appears that "North American Geology" is compressed into 100 pages, including 16 on "definitions and laws of geology," and 10 on the subject of "nomenclature" of fossils, whilst the remainder of the work, if we except the glossary and index, is devoted to "North American Palæozoic Fossils."

This part is further subdivided. The "Vegetable Kingdom" forms a section by itself: the "Animal Kingdom" is portioned out into zoological subkingdoms, under each of which the genera are arranged alphabetically, and prefaced by general remarks on the group.

The alphabetical method in a work intended for students has its advantages; nevertheless, since the zoological arrangement of the subkingdoms necessitates the addition of an idea for the benefit of the tyro in palæontology, it is hard to see why the whole should not either have been carried out on the dictionary plan or systematically disposed.

The chapter on nomenclature practically popularizes the British Association rules, but we do not call to mind in that code any retrospective regulation to the effect that "a name should always be rejected when it outrages decency." It is true names were coined in early days of natural history which no right-minded person would even think of inventing now-a-days; but if they pass current to-day, it is assuredly not because their extraction is thought of; they are names and nothing more, and to seek to alter them now would be to needlessly imitate those maiden ladies of America who draped their table-legs and studiously avoided all mention of the naked eye.

Puns are abhorrent to the author, who decrees that "Latin puns on names, as faba after Mr. Bean, should be rejected in all cases as a poor joke." "Buffoonery," we are told, "has no place in science." And yet somehow or other we cannot quite disabuse our minds of the impression that the author himself is attempting to play off a big joke on the geological student.

How else are some of the following statements to be accounted for? "The Palæozoic Protozoa are included in two classes, viz. Rhizopodæ and Poriferæ." "The Poriferæ include the Sponges and are not to be regarded as any more highly organized than the

Rhizopodæ." Again, after strenuously upholding the law of priority (p. 92), he proceeds to remark à propos of *Orophocrinus* (p. 265), "The definition was very imperfect and was made in a foreign language, in a foreign country, and in a journal having no circulation in America where the fossil occurs," and proceeds to conclude that this name must give way to *Codonites*, Meek & Worthen, 1869!

The list of families given at the head of each section is sometimes remarkable, those into which he distributes the Palæozoic Sponges is especially so. Some of these families have not yet been described and are given with all their species marked "(in press)." The Beatricidæ (with the single type genus) and the Stromatoporidæ have long been removed from the Sponges, and *Palæacis*, here the sole genus of a family, is generally considered to be a Coral. The Pharetrones are calci-sponges, but not one of the four genera here referred to them is. In the class Crinoidea, the genus *Melocrinus* does not appear with the other genera under Melocrinidæ, but under Actinocrinidæ, whilst *Taxocrinus* appears under two families—Ichthyocrinidæ and Taxocrinidæ!

In the Gasteropoda the genus *Turbo* is illustrated by the type species *T. marmoratus*, and fully described, the paragraph concluding with the following gem: "Not an American Palæozoic genus. The species left here is, for want of material, to refer them to where they belong"!

Under "Lamellibranchiata" we learn that "Shells having a siphon are always gaping at the posterior or anterior side, or at both"! *Arca* is "unknown in the Palæozoic rocks," and *Cucullæa* "is not a Palæozoic genus." Under "Pisces" we find the synonyms *Mecolepis* and *Eurylepis* given as distinct genera, and the species put under the former all repeated under the latter.

The palæontological part of the work is extensively illustrated by figures drawn from every available source, and consequently of very unequal value, a few being as excellent as the majority are the reverse. They will probably prove more useful as "reminders" to the palæontologist than as aids to the identification on the part of the student.

In this edition, whilst the etymology of the generic names is given in the text, that of the specific is gathered into a glossary, endless repetition being thereby avoided. Here emendation is as necessary as in the rest of the volume. To find that 'adnatus' means 'adnate,' 'basalticus' is 'basaltic,' and that 'chrysalis' is 'chrysalis,' may be satisfactory to some minds, but can hardly be called explanatory. The translation of 'bipartitus' into 'two-parted' is not very happy, whilst the rendering of 'perspicator' by 'sharp-sighted' is hardly as correct as it should be. The inflections attributed to certain comparative adverbs as 'minus, a, um, less' are novelties that will interest the philologist without, however, instructing the youth to whom the little book is dedicated.

Notwithstanding all its faults, the book has considerable value as a work of reference to the literature of North American Palæozoic Palæontology, and in the hands of a moderately competent editor would become a priceless treasure to the working palæontologist.

III.—A Guide to the Exhibition Galleries of the Department of Geology and Palæontology of the British Museum (Natural History), Cromwell Road, London, S.W. Part I. Fossil Mammals and Birds. With 119 Illustration and 1 Plan; 103 pages, 8vo. Part II. Fossil Reptiles, Fishes, and Invertebrates. With 94 Illustrations and 1 Plan; 109 pages, 8vo. Price Sixpence each Part. Printed by Order of the Trustees, April, 1890.

THE Trustees and Officers of the British Museum have in many ways shown their earnest desire to render the collections under their care as useful as possible, both to students and the general public. The Natural-History branch of the Museum provides useful "Handbooks" and "Guides," besides more elaborate "Catalogues," and the Department of Geology and Palæontology is well furnished with such necessary means of instruction, suited both to save the time of the amateur who wishes to learn what the specimens in the Cases have to teach, and to direct the student at once to those parts of the Collection that will serve to increase his knowledge. A "Guide" to the Department was issued in 1881, and the four successive editions, each illustrated and enlarged, that have followed, have been well appreciated by the public, for 15,000 copies have been issued. Of late years many interesting and rare Fossils have been added to the Collection, and "Museum Catalogues" of Fossil Mammalia, Reptilia, Amphibia, Fishes, Crustacea, Cephalopoda, Blastoidea, Sponges, Foraminifera, and Coal-plants have more particularly been prepared technically and scientifically by various specialists. The new edition of the Guide-book has necessarily been augmented with notices of the chief types and varieties of the vertebrate animals mentioned in those Catalogues and elsewhere; and gives references to the subject-matter of such Catalogues and special works as elucidate the structure and characters of the Invertebrata. So much indeed has this hand-book increased that it is now published in two parts, each of which is larger than the former "Guide." Part I. contains 116 woodcuts and a frontispiece; Part II. has 94 woodcuts. In the "Guide" (especially in the first part), figures of recent specimens are placed near those of the fossils in several instances for comparison, and to enable the beginner to compare what is easily known with the more obscure and often imperfect remains of extinct forms.

If any fault can be found with regard to the number of illustrations, it is that in some cases they appear to be excessive. Thus, in treating of the order Chelonia, in pt. ii. pp. 38–41, we find a number of illustrations which do not seem necessary to explain the text, and, indeed, are, for the most part, not even mentioned therein. The greater number of the excellent illustrations with which the work is adorned have been reproduced from the recently-published 'Catalogues' of Fossil Mammalia, Reptilia, and Amphibia; but a few, such as the skull of *Samotherium* and the skeleton of *Lariosaurus*, have been executed specially for the present work. We may mention that the fourth part of the 'Catalogue of Fossil Reptilia and Amphibia' was still in the press at the time of publication of the 'Guide,' but numerous figures of Reptiles and Labyrinthodonts have been taken therefrom, and the author has had the opportunity of seeing the proof-sheets. This will account for the appearance in part ii. pp. 65–66, of the new name *Metoposaurus*, which has been proposed in the 'Catalogue' to replace the preoccupied one of *Metopias*.

In the great majority of instances some explanation is given of the structure and affinities of the genera mentioned; but in some cases we venture to think such explanations are somewhat too technical to suit the popular taste; while in others we meet with lists of names without any distinct clue as to what kind of creatures they really represent.

The first part is devoted to the consideration of the Mammals and Birds; the former coming in for a very full treatment, both as regards letterpress and illustrations. We are glad to see a very considerable advance in the systematic treatment of this group, the author having for the most part brought his descriptions fully abreast of the modern views. We may notice, however, that the introduction of the discarded term Quadrumana on page 4 appears unnecessary, and liable to lead to confusion. And on the same page, we think, it would have been advisable to point out which genera of Monkeys and Apes are still living and which are extinct, and also to have arranged them according to their families. Thus we find *Anthropopithecus* (Chimpanzee) separated from its extinct ally *Dryopithecus*; while the extinct *Mesopithecus* should have occupied, as its name implies, the middle position between the living *Macacus* and *Semnopithecus*.

A large series of figures illustrates very fully the gradual advance in the specialization of the molar teeth of the Proboscideans; a group of which the Museum contains the finest collection extant. In speaking of the *Macrauchenia*, at p. 30, as a specialized Ungulate, we presume the author rather intended to use the term "generalized." Again, in treating of the Horses, at p. 39, the author appears to have become involved in some confusion between *Equidæ* and *Lophiodontidæ*, since he mentions the genus *Eohippus* among the former family, whereas its true position is in the latter. We may mention in passing that the recent observations of Messrs. Scott and Osborn have shown that *Eohippus* is really identical with *Hyracotherium* (p. 38); *Orohippus* being the same as *Pachynolophus*. The new views as to the probable Metatherian affinity of the Mesozoic Multituberculata are adopted. Why the author will persist in using the name *Castor europæus*, Owen (p. 9), in place of *C. fiber*, Linn., is a point on which we should be glad to receive further information.

In the Birds the classification of the extinct and recent types proposed by Prof. A. Newton has been followed; the presence or absence of teeth not being regarded as features of ordinal importance.

The second part is devoted to the Reptiles (including Amphibians), Fishes, and Invertebrates. Since, however, a special guide to the Fossil Fishes has been already published, mention is only made of the chief groups into which the class is divided. The same brevity is noticeable in regard to the Invertebrates; and there is also a short notice of the Fossil Plants. The concluding sections of this part refer to the very interesting historical and stratigraphical collections exhibited in the Department. The fine series of fossil footprints is also mentioned; and in this connection we notice that the student is liable to be misled by the unfortunate slip of the name *Cheirotherium* occurring in the text, while the explanatory illustration bears the legend *Chirosaurus.*

The author in treating of the Reptiles and Amphibians follows in the main the classification adopted in the Museum Catalogues. In retaining the name *Ornithopsis* (p. 10) in place of the earlier *Hoplosaurus* (p. 12) the author sets, however, a false precedent, since if we do not hold by the rule of priority there is not the least reason why *Ornithopsis* itself should be held preferable to *Eucamerotus*; indeed the reverse is the case, since the remains on the evidence of which the name *Ornithopsis* was proposed were never figured by their describer, while those described as *Eucamerotus* were fully illustrated.

The magnificent series of Ichthyosaurian and Pliosaurian remains preserved in the Museum meets with full recognition; the illustrations indicating the chief structural peculiarities of these groups. The description of the anatomical structure at p. 33 is, however, one of those instances to which we have already alluded where the technicalities seem to be too great. Thus we very much doub whether the ordinary reader will have the slightest idea what an 'obturator notch,' or a 'precoracoid' means. If indeed such terms are introduced at all in a work of this nature, they should be fully explained and illustrated by diagrams.

In raising the peculiar Placodonts to the rank of an order, the author departs from the usual view without any sufficient justification. In the diagnosis of the order Anomodontia we again deplore the extreme technicality of the terms, and venture to affirm that these will be utterly unintelligible to the ordinary visitor, while the student will of course seek elsewhere for his information. If such technicalities are admissible at all, it should surely have been clearly explained by the aid of a figure that the precoracoid of many Anomodonts differs from that of all other Reptiles in being an absolutely distinct bone. The features in which these Reptiles approximate to the Monotreme Mammals might also have been advantageously indicated, as they are the most interesting points in connection with the group. A protest must also be entered against the decisive reference of the Karoo System of the Cape to the Trias, in face of the arguments brought against this view by Mr. W. T. Blanford and others. Some of the figures illustrating the osteology of the Anomodonts are all that can be desired.

Notices of historical and type collections, and of stratigraphical and other special groups of specimens, at pages 92–100, comprise remarks on Sir Hans Sloane's, Brander's, William Smith's, Sowerby's, Gilbertson's, Searles Wood's, F. E. Edwards', and Davidson's collections; besides the specimens of König's "Icones," bored rocks, tracks, trails, footprints, cores from borings, etc.

The descriptive paragraphs not only give details as to the localities and peculiarities of the fossils, but are frequently rich with philosophic thought on the relationship and probable descent of the animals themselves.

Each Part contains a plan and explanation of the saloons or galleries and cases of those fossils of which it treats, also a good index; and is complete in itself.

In thus endeavouring to popularize an abstruse but exceedingly fascinating branch of science, and in giving to the public such a full shilling's worth, the author (Dr. H. Woodward) and the Trustees of the British Museum are to be highly congratulated; and we trust that the public will show its appreciation of the work by rapidly buying up the present edition, and thus enabling the author to issue another edition incorporating some of the slight improvements we have ventured to suggest.

A list of the Museum Catalogues relating to Zoology and Palæontology, and of Guide-books for the Zoological, Geological, and Mineralogical Departments, is added.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 16, 1890.—J. W. Hulke, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On the disturbed Rocks of North-western Germany." By Prof. A. von Könen, For.Corr.G.S. (Communicated by Sir Warington W. Smyth, F.R.S., F.G.S.)

After referring to the disturbances of Palæozoic times, the author commented upon the Miocene dislocations of the Harz, Rhineland, Westphalia, and Nassau, which have a N.W.–S.E. strike, varying to N.–S. or E.–W., and which are similar to post-Glacial dislocations.

He briefly discussed the origin of these dislocations, and noticed their peculiarities, and proceeded to consider the relationship of the intruded basalts to the disturbances, supposing that during the process of faulting, the earth's crust was pressed downward along synclinal lines, and that the basaltic magma escaped upwards through the inverted funnel-shaped synclinal fissure.

Comparison was made between these Tertiary basalts and the products of modern volcanic eruptions, and it does not appear to the author to be unlikely that the cause of the outflow of many of the lavas in the latter was similar to that which produced the extension of the Tertiary basaltic rocks.

2 "On the Origin of the Basins of the Great Lakes of America." By. Prof. J. W. Spencer, M.A., Ph.D., F.G.S., State Geologist of Georgia.

From the study of the hydrography of the American lakes, from the discovery of buried channels revealed by borings, from the inspection of the glaciation of the lake-region, the consideration of the late high continental elevation, and the investigation of the deformation of old water-levels, as recorded in the high-level beaches, the explanation of the origin of the basins of the great lakes becomes possible.

The original Erie valley drained into the extreme western end of Lake Ontario—the Niagara river being modern—by a channel now partly buried beneath drift. Lake Huron, by way of Georgia Bay, was a valley continuous with that of Lake Ontario; but between these two bodies of water, for a distance of about 95 miles, it is now buried beneath hundreds of feet of drift. The old channel of this buried valley entered the Ontario basin about twenty miles east of Toronto. The northern part of Lake Michigan basin was drained into the Huron basin, as at present; whilst the southern basin of the lake emptied by a now deeply drift-filled channel into the south-western part of Huron. The buried fragments of a great ancient valley and river, and its tributaries, are connected with submerged channels in Lake Huron and Lake Ontario, thus forming the course of the ancient St. Lawrence (Laurentian) river, with a great tributary from the Erie basin and another across the southern part of the State of Michigan. This valley is of high antiquity, and was formed during times of high continental elevation, culminating not long before the Pleistocene period. The glaciation of the region is nowhere parallel with the escarpments, forming the sides of, or crossing the lakes or less prominent features. During the Pleistocene period, and especially at the close of the episode of the Upper Till, the continent was greatly depressed, and extensive beaches and shore-lines were made, which are now preserved at high elevations. With the re-elevation of the continent these old water levels have been deformed, owing to their unequal elevations. This deformation is sufficient to account for the rocky barriers at the outlets of the lakes. Some of the lakes have been formed, in part, by drift obstructing the old valley. The origin of the basins of the Great Lakes may be stated as the valley (of erosion) of the ancient St. Lawrence River and its tributaries, obstructed during, and particularly at the close of the Pleistocene period, by terrestrial movements, warping the earth's crust into barriers, thus producing lake-basins, some of which had just been formed in part by drift deposited in the ancient valley.

3. "On Ornithosaurian Remains from the Oxford Clay of Northampton." By R. Lydekker, Esq., B.A., F.G.S.

Seven vertebræ, portions of the ilia and ischia, one femur, and the distal portion of that of the opposite side, part of a bone, probably from the shaft of the tibia, and two undetermined fragments, all associated, indicate the existence in England during the Oxford-clay period of the species of *Rhamphorhynchus* provisionally referred to *R. Jessoni*, though not definitely distinguished from *R. Gemmingi.*

Amongst the noticeable features of the specimens are the presence of a distinct rib-facet at the lateral border of the inferior surface of the centrum of the cervical vertebræ, proving the existence of cervical ribs, and the character of the neural spine of a dorsal vertebra which strikingly recalls that of a bird.

4. "Notes on a 'Wash-out' found in the Pleasley and Teversall Collieries, Derbyshire and Nottinghamshire." By J. C. B. Hendy, Esq. Communicated by Dr. W. T. Blanford, F.R.S., F.G.S.

Sections were given of the "Wash" showing the thickening of the coal as it approaches the same, and the splitting of the "Wash" itself into two branches. Various measurements were noted, and certain disturbances recorded. In every section examined, the sides of the "Wash" are more or less slickensided, and in some few cases the coal is distorted next to the "Wash"; but the author is of opinion that these are due to lateral pressure and movement subsequent to the denudation of the coal and deposition of the sandstone, and he remarks on the difficulty of reconciling the regularity of the underclay with the theory of the formation of "Washes" by disturbance.

He considers that they are due, in Durham and elsewhere, to currents flowing at a high rate of speed in one direction, carrying away the denuded material, and, as in the case of the Derbyshire "Wash," to a series of inundations, each inrush denuding a certain amount, and on subsiding, redepositing part of the material at a higher level, while the remainder was carried away in suspension.

In conclusion, notice was taken of "washes" occurring in other localities.

II.—April 30, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "On certain Physical Peculiarities exhibited by the so-called 'Raised Beaches' of Hope's Nose and the Thatcher Rock, Devon." By D. Pidgeon, Esq., F.G.S.

The author described the peculiarities of these so-called beaches, including the absence of stratification, the presence of splinters of rock like that of the overlying limestone cliffs, the scarcity of rounded pebbles, and the great abundance of sharply fractured shells associated with unbroken rock-dwelling shells.

He enumerated the fossils collected from these deposits by Mr. A. R. Hunt, which include *Trophon truncatus* and *Pleurotoma turricula*, and calling attention to the observations of Messrs. Feilden and De Rance, and of Dr. Moss upon the ice-foot of Arctic regions, and the accumulation of material in the trenches found therein, concluded that the deposits under consideration were formed at a time when a small bay existed between Hope's Nose and the Thatcher Rock, which has since been destroyed by denudation of the intervening sandstone, in which bay an ice-foot once existed; and further, that the two deposits from the surviving relics of the mingled mass of chips, shells, shell-fragments, Crustacea, etc., which must have filled the trench in the ice-foot demanded in such a position. This would place the time of formation of the deposits at the close of the Glacial period.

2. "The Devonian Rocks of South Devon." By W. A. E. Ussher, Esq., F.G.S., of H.M. Geological Survey.

This paper is the result of work done in continuation of the labours of the late Mr. Champernowne, and refers particularly to the area north of the Dart and east of Dartmoor.

Owing to the complicated stratigraphy of the region, we have to fall back upon such information as can be procured of the general types of Upper, Middle, and Lower Devonian faunas; for though the lithological constituents of these three divisions are broadly distinguishable, there are no definite lithological boundaries between them.

The Lower Devonian is mainly distinguished by the occurrence of sandstone and grit, but the upper beds are shales passing into the Middle Devonian slates.

The Middle Devonian consists of limestones, and shaly limestones upon slates, the latter representing the Calceolen-Schiefer, and containing *Spirifer speciosus*. *Stringocephalus* is found here and there in the Middle Devonian Limestones. The upper part of the Middle Devonian Limestones (with Lummaton fauna) passes into the *cuboides*-beds of the Upper Devonian. The Upper Devonian contains thin-bedded limestones, often concretionary, with chocolate-red and pale greenish slates and mudstones. These beds correspond to the Goniatiten-Schichten, Kramenzelstein and Knollenkalk of Germany, and to the Cypridinen-Schiefer.

In the Upper and Middle Devonian rocks we find a local prevalence of schalstein ard tuffs, breaking up the limestones. The slate and sandstone type of Upper Devonian in North Devon appears to give place southward to a purely slate type, possibly accompanied by overlap of the Culm-measures. The author groups the South Devon rocks under the following heads:—

Upper ...	1. Cypridinen-Schiefer.
	2. Goniatite-limestones and slates.
	3. Massive Limestones.
Middle ...	4. Ashprington Volcanic Series.
	5. Middle Devonian Limestones.
	6. Eifelian slates and shaly limestone.
Lower ...	7. Slates and sandstones, generally red.
	8. Slates with hard grits.

After discussing the relationship of the Lincombe and Warberry beds and the New Cut Homalonotus-beds, the author notes the discovery of *Pleurodictyum* by Mr. Whidborne in the railway-cutting at Saltern Cove. He proves the Lower Devonian age of the Cockington beds and their correlation with the Torquay Lower Devonian by the discovery of fossils. He considers it probable, though not certain, that the main mass of Meadfoot beds is below the Lincombe, Warberry, and Cockington sandstones.

The distribution of the Middle Devonian Limestones is described. *Stringocephalus* is found in limestones containing *Rhynchonella cuboides*. The upper parts of the limestone-masses (East Ogwell, Kingskerswell, Barton, Ilsham, etc.) may be Upper Devonian. The massive limestones may terminate abruptly or pass laterally into shales, and the whole mass of the limestones seems to be replaced by slates between the Yealmpton and Totnes areas.

The commencement of the phase of volcanic activity which caused the accumulation of the Ashprington series is shown to coincide with the latest stage of Eifelian deposition, and the Ashprington series may represent continuous or intermittent vulcanicity up to a late stage in the Upper Devonian. North of Stoke Gabriel a mass of limestone seems to have been formed contemporaneously with the volcanic material on the immediate borders of which it occurs. Elsewhere the limestones are interrupted by local influxes of volcanic material. The occurrence of other local developments of Middle and Upper Devonian volcanic rocks is described.

The relationship of the Middle and Upper Devonian deposits varies. In some cases Upper Devonian shales may have been deposited against Middle Devonian limestones; in others there is a continuous development of limestone, the Middle Devonian limestones being succeeded by *Cuboides*-beds, *Goniatite*-limestones, and Knollenkalk. The local variations of these are described, and fossil-lists given. The Knollenkalk is shown to pass under *Entomis*-bearing beds ("Cypridinen-Schiefer"), which are described, though a detailed account of their relationship to the Culm-measures is reserved for a future occasion.

III.—May 14, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read :—

1. "The so-called Upper-Lias Clay of Down Cliffs." By S. S. Buckman, Esq., F.G.S.

The blue clay of Down Cliff, Dorset, which has been referred to the Upper Lias, has yielded Ammonites of the genus *Dumortieria* to the author, notably *D. radians*. This blue clay is *below* the Yeovil Sands; but the position of *D. radians* in the Cotteswolds is in the limestone *above* the Cotteswold Sands, which has been placed in the Inferior-Oolite series.

The author, by combining the Down-Cliffs and Chideock-Hill sections, obtains a sequence of beds from the Middle Lias to the top beds of the Inferior Oolite, including the zones of *spinatum*, *commune* and *falciferum*, *jurense*, *opalinum*, *Murchisonæ*, *concavum*, and *Parkinsoni*.

The genus *Dumortieria* binds the *opalinum*- and *jurense*-zones together; while at Symondsbury Hill the author has found *Ludwigia Murchisonæ* and *Lioceras opalinum* in the same bed, which renders it difficult to draw a line of demarcation between Lias and Oolite at the top of the *opalinum*-zone.

The facts adduced in the paper furnish additional evidence of the unreliability of a grouping which depends upon lithological appearances, and it was because no satisfactory line could be drawn between Lias and Oolite that the author, in a previous paper, supported the continental plan of grouping Upper Lias and part of the Inferior

Oolite under the term Toarcian upon palæontological grounds. In the present paper he furnishes further statements in support of this view.

2. "On some new Mammals from the Red and Norwich Crags." By E. T. Newton, Esq., F.G.S.

This paper contains descriptions of mammalian remains from the English Pliocene belonging to eight species, nearly all being new to the Crags, and four of them new to science. A remarkable low-crowned, but broad, lower carnassial tooth from the Norwich Crag of Bramerton is referred to the genus *Lutra*, and named specifically *L. Reevei*. All the other specimens noticed below are from the nodule-bed at the base of the Suffolk Red Crag, and the first four of them are in the possession of Mr. E. C. Moor, of Great Bealings. A right ramus of a lutrine lower jaw, differing from the common Otter in having the hinder fangs of the premolars much larger than the front ones, and agreeing in this particular with the *Lutra dubia* of De Blainville, is referred to the latter species. A humerus of a Seal, most nearly resembling that of *Phoca vitulina*, but of smaller size and more slender proportions, is called *Phoca Moori*. Another Seal's humerus, having a peculiarly triangular shaft, is thought to belong to the *Phocanella minor* of Van Beneden. A maxilla with three teeth, evidently belonging to the genus *Trogontherium*, but of smaller size than the *Trogontherium Cuvieri*, is believed to represent another species, and is named *T. minor*. The ziphioid rostrum in the Ipswich Museum, which received from the Rev. H. Canham the MS. name of *Mesoplodon Floweri*, is for the first time described; and another rostrum in the Museum of Practical Geology, characterized by being very short and with a deep boat-like anterior extremity, is named *Mesoplodon scaphoides*. The peculiar species *Ailurus anglicus*, hitherto known only by a piece of a lower jaw with a carnassial tooth, is now further illustrated by a fine upper molar recently presented to the Museum of Practical Geology.

3. "On Burrows and Tracks of Invertebrate Animals in Palæozoic Rocks, and other Markings." By Sir J. William Dawson, LL.D., F.R.S., F.G.S.

This paper, which is illustrated by photographs and drawings, indicates some new facts in connection with the markings produced by the burrows and tracks of animals and by other causes. *Rusichnites* and *Cruziana* are regarded, like *Climactichnites* and *Protichnites*, as representing probable burrows of Crustaceans and Chætopod worms. *Scolithus canadensis* is shown to be a cylindrical burrow, with accumulations of earthy castings at its mouth. The relation of these burrows to the forms knows as *Scotolithus, Asterophycus, Monocraterion*, and *Astropolithon* is pointed out.

Under the new generic name of *Sabellarites* the author describes certain tubes, composed of shelly and other fragments cemented by organic matter, found in the Trenton Black-river Limestone. They resemble the burrows or tubes formerly described by the author from the Hastings and Quebec Groups, and appear to be the tubes of worms allied to the recent *Sabellariæ*; but they are liable to be mistaken for Algæ of the genera *Palæophycus* and *Buthotrephis*.

Some large cylindrical bodies from the Potsdam Sandstone are described as having been supposed to be trunks of trees; but the author regards them as probably concretions formed around slender stems, like some now forming in the alluvial mud of the St. Lawrence.

Some curious combinations of worm-tracks with ripple-marks and shrinkage-tracks are described; as also branching or radiating worm-trails, which present some resemblance to branching Fucoids. Finally the author described the formation of rill-marks on the mud-banks of the tidal estuaries of the Bay of Fundy, and indicates their identity with some impressions in slabs of rock which have been described as Fucoids under several generic names.

4. "Contact-alteration at New Galloway." By Miss M. I. Gardiner. Communicated by J. J. H. Teall, Esq., M.A., F.G.S.

A description is given of an alternating series of grits and shales occurring at the eastern end of the northern edge of the Cairnsmore of Fleet granite-mass. The rocks here are generally more altered than around other parts of the granite margin. The author describes a transverse section about half a mile from the granite, and traces the changes which occur in the rocks when passing towards the granite. She notices (1) the extreme variation in the amount of alteration in different places, but at the same distance from the granite; (2) the entire recrystallization, in one locality, of the shales for about 2 feet and of the grits for about 100 yards from the granite margin; that material seems to have travelled through the rock, so that the most altered grit largely consists of crystals, here of one mineral, there of another, as though material had been conveyed from one part of the rock to another to form small nests; (4) the apparent order of succession of the minerals, garnets rarely containing anything but colouring-matter and quartz, chiastolite containing garnets, and bands of mica sweeping round both; (5) evidence which appears to the author to indicate dynamic metamorphism, as furnished by the sigmoidal folding of knots in the shales and by the appearance of phenomena suggesting thrust-planes.

The author considers, however, that the main metamorphism is due to the intrusion of the granite, and that the variation in the amount of alteration at the same distances, the mode of alteration of the grits, and the transference of material might be accounted for by the passage of highly heated water. Other evidence points to the changes having been brought about slowly.

Among the minerals produced in the contact-zone are secondary quartz, felspar, brown and white micas, chiastolite, sillimanite, and garnet, their modes of occurrence being described in detail, in rocks of various degrees of alteration up to those in an abnormally high state of alteration near the granite, which resemble rocks of doubtful origin in other localities.

CORRESPONDENCE.

PROCEEDINGS OF THE COTTESWOLD NATURALISTS' FIELD CLUB.

Sir,—Over the familiar initials H. B. W. appears a notice of the above Club, vol. ix. pt. iv. (Geol. Mag. Dec. III. Vol. VII. p. 88). A large part of this notice is, I am sorry to see, occupied in a criticism upon my system of nomenclature.

Mr. H. B. W. is, really, not complimentary to the members of the Cotteswold Field Club. He leads us to imagine that they are unable to cope with anything which has not been thoroughly approved of, and digested by, the text-books, not as if one were writing for scientific men, but as if one were addressing the raw students of a newly-formed Natural History class.

Another idea which H. B. W. puts forth is, that there shall be really two systems of nomenclature—one for the use of specialists among themselves, and the other for the consumption of stratigraphists and general readers. Already there are complaints that one system is enough to remember; now we are to have two, to be varied according to the supposed capacities of the audience! What would be the result? The stratigraphist would soon be unable to comprehend the palæontologist, instead of being gradually educated up to him, as at present.

I can, however, throw out one suggestion whereby all authors can help the general reader, namely, by differentiating, in lists of fossils, Brachiopoda, Cephalopoda, etc., by the use of those terms as headings; or, sometimes, by indicating smaller divisions, such as Ammonites, Goniatites, Nautili. The general reader would know then, at any rate within some limits, to what an unknown generic name applied. This suggestion, however, is quite as necessary to those using old, as to those employing new, generic names.

S. S. Buckman.

OBITUARY.

JOHN EDWARD TENISON WOODS.

One of the pioneers of Australian geology has passed away by the death of the late Vicar-general of Adelaide. Mr. Woods first settled in Australia about 1857, and in that year issued his paper, "Observations on some Metamorphic Rocks in S. Australia." This was followed by others, "Geological Observations on S. Australia," in 1862, and by his "Tertiary Fossils of South Australia," in 1865. His greatest work, "A History of the Discovery and Exploration of Australia," was published in 1862, and besides being a most useful compilation, it contained some valuable additions to Australian palæontology. In 1867, in a paper on "The Glacial Deposits in Australia," he made the first attempt to prove the past existence of an Ice age in that Continent. In later years Mr. Woods rather abandoned geology, but he did much good work on the recent mollusca of Australia and Tasmania. He was also interested and wrote occasionally on meteorology. In 1880 he served as President of the Linnean Society of New South Wales. He died at Sydney on the 9th of October, 1889.

Verlag von **Wilhelm Engelmann** in Leipzig.

W. C. Brögger

Die Mineralien der Syenitpegmatitgänge

der

südnorwegischen Augit- und Nephelinsyenite.

(Zeitschrift für Krystallographie und Mineralogie, herausgegeben von P. Groth, XVI. Band.)

Mit 58 Textillustrationen,
27 lithographischen Tafeln und 2 geologischen Karten. gr. 8°.

Preis *M* 40 für Abnehmer der Zeitschrift;
» » 60 für Nichtabnehmer derselben.

Die vorstehend angezeigte Publikation wird zweifelsohne für die naturwissenschaftliche Kenntniss Skandinaviens von epochemachender Bedeutung werden. Das Christianiagebiet ist bekanntlich in geologischer und mineralogischer Beziehung eines der interessantesten auf der ganzen Erde, und die grössten Geologen, L. von Buch, C. F. Naumann, Ch. Lyell, R. J. Murchison, Th. Scheerer (um nur Verstorbene zu nennen), sammelten hier Beobachtungen, welche für die Entwicklung der geologischen Anschauungen von fundamentaler Bedeutung wurden. Die Mineralien der Gegend von Brevik, Fredriksvärn u. a. Orten boten das Material für viele der unvergesslichsten Entdeckungen von Berzelius, und reihten, namentlich durch die Bemühungen des Pfarrers Esmark in allen Sammlungen verbreitet, die einzelnen Fundorte jener Gegend unter die berühmtesten, welche überhaupt existiren, ein. Die grundlegende Kenntniss des geologischen Aufbaues verdankt man besonders den Forschungen B. M. Keilhau's und Th. Kjerulf's, namentlich in der ersten Hälfte und während der fünfziger und sechziger Jahre unseres Jahrhunderts. Seitdem sind jedoch die Hülfsmittel, welche die Mineralogie und die mikroskopische Petrographie der geologischen Forschung darbieten, so vervollkommnet worden, dass zu erwarten war, eine erneute Bearbeitung jenes wichtigen Gebietes werde noch vieles Neue erkennen und manche noch zweifelhafte Frage entscheiden lassen. Von diesem Gesichtspunkte ausgehend hat Herr W. C. Brögger, Professor der Mineralogie und Geologie an der Hochschule Stockholm, früher in Christiania und Schüler Kjerulf's, seit 15 Jahren es sich zur Aufgabe gemacht, die merkwürdigen Minerallagerstätten jener seiner engeren Heimath spezieller zu erforschen, und eine Reihe vorläufiger Mittheilungen über neu entdeckte Mineralien liessen bereits erkennen, welche Fülle neuer und wichtiger Beobachtungen ihm gelungen war. Auf Grund umfassender Aufsammlungen an Ort und Stelle, durch Benutzung des von Freiherrn von Nordenskiöld zur Verfügung gestellten reichen Materials des Reichsmuseums und mit Hülfe der Untersuchungen einer Reihe von hervorragenden Chemikern, wie Professor Cleve, Blomstrand u. A., welche die zugehörigen Analysen übernahmen, ist nun das vorgenannte Werk entstanden, auf dessen Inhalt im Folgenden mit einigen Worten hingewiesen werden soll.

Ein allgemeiner Ueberblick über die Geologie des Christianiagebietes lehrt uns, dass dasselbe einen zwischen dem östlich und westlich davon gelegenen Grundgebirge eingesunkenen Landstreifen bildet, zusammengesetzt aus silurischen Schichten und aus, diese durchsetzenden, Eruptivgesteinen. Auf Grund zahlloser Einzelbeobachtungen wird nun das relative Alter dieser verschiedenen Bildungen bestimmt und zum ersten Male eine exacte Unterscheidung der mannigfachen, daselbst auftretenden Eruptivgesteine durchgeführt, welche schon desshalb ein besonderes Interesse haben, weil die Mehrzahl derselben Typen darstellen, die auf der ganzen übrigen Erde unbekannt sind. Das wichtigste Resultat dieses Theils der Untersuchung besteht nun darin, dass sich eine stetige Aenderung der Beschaffenheit jener Gesteine mit ihrem geologischen Alter zeigte, welche auf einen genetischen Zusammenhang der aufeinanderfolgenden Eruptionen hinweist. Als einzig mögliche Erklärung der complicirten, in dem ganzen Gebiete herrschenden Verhältnisse ergiebt sich die Annahme, dass unter demselben lange Zeit hindurch ein von einem allgemeinen gluthflüssigen Erdinnern abgesperrtes Bassin vorhanden gewesen, aus welchem durch Einsinken der darüber befindlichen festen Massen das geschmolzene Magma nach und nach hinaufgepresst worden sei, — und es wird ausführlich nachgewiesen, wie die Verschiedenheit der Zusammensetzung der einzelnen Eruptionen sich durch die nothwendig erfolgenden Aenderungen in dem »Magmabassin« erklären lassen.

An diese Bildungsgeschichte des Christianiagebiets schliesst sich nun die Geologie der syenitischen und nephelinsyenitischen Pegmatitgänge der Küste zwischen dem Christianiafjord und dem Langesundfjord an. Durch das sorgfältige Studium der eigenthümlichen Structurverhältnisse dieser

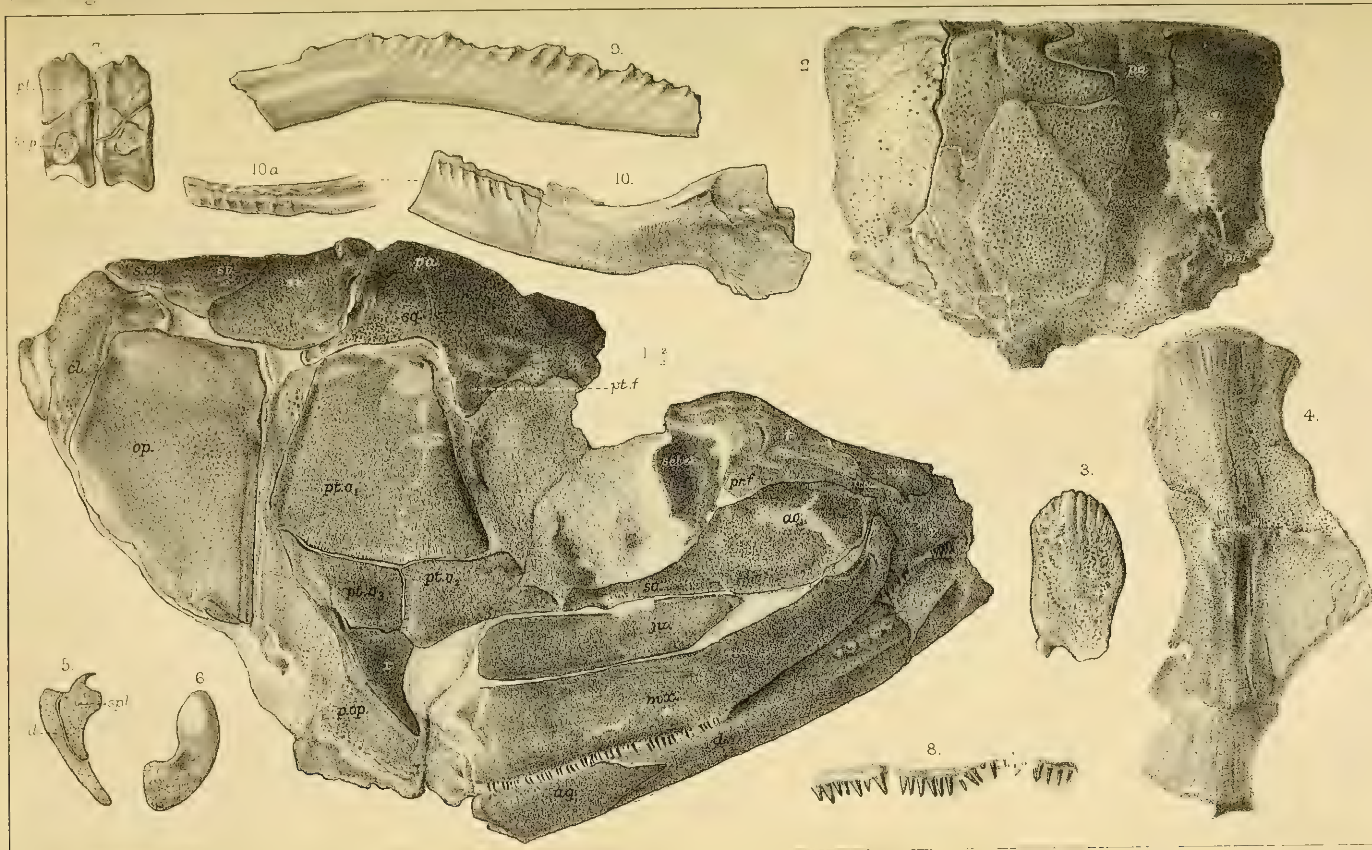
Gesteinsgänge, ihres Verhaltens zu den Schichten, welche von ihnen durchbrochen wurden, u. s. w. wird gezeigt, dass es sich hier um wahre eruptive Gesteine handelt, welche aus einem Magma aufgedrungen und in Spalten erstarrt sind, und dass sich dieselben mit denjenigen Gesteinen in Zusammenhang bringen lassen, welche als mächtige Eruptivmassen einen so wichtigen Antheil an dem Aufbau des ganzen Gebietes nehmen. Die Masse dieser Gänge entstammt also dem gleichen Magmabassin, dessen Inhalt zum Theil in zahlreiche Spalten der darübergelagerten Gebirgsmassen eingepresst wurde und hier unter ganz besonderen Verhältnissen erstarrte. Dadurch sind nun auf diesen Gängen jene merkwürdigen Mineralcombinationen entstanden, welche bisher so räthselhaft schienen und die Aufmerksamkeit der Mineralogen seit dem Beginn des Jahrhunderts auf sich zogen. Deren eingehende Untersuchung bildet den umfangreichsten Theil des Werkes. Von der Fülle der hier niedergelegten Einzelbeobachtungen kann natürlich an dieser Stelle keine Rechenschaft gegeben werden: es genüge darauf hinzuweisen, dass der spezielle Theil des Buches nicht weniger als 73 monographische Mineralbeschreibungen mit 27 Tafeln krystallographischer und mikroskopischer Abbildungen umfasst und dass in der mineralogischen Literatur wohl noch kein Werk existirt, welches eine ähnliche Summe wichtiger Forschungsresultate in sich vereinigt.

Zu Bestellungen wolle man sich des nachstehenden Zettels bedienen.

Leipzig, April 1890.

Wilhelm Engelmann.

Druck von Breitkopf & Härtel in Leipzig.



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

1- 8. Eurycormus grandis, *A. Smith Woodward.*
1- 10. Leedsichthys problematicus, *A. Smith Woodward.*

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VII.

No. VII.—JULY, 1890.

ORIGINAL ARTICLES.

I.—On a Head of *Eurycormus* from the Kimmeridge Clay of Ely.[1]

By A. Smith Woodward, F.G.S., F.Z.S.;
of the British Museum (Natural History).

(PLATE X. Figs. 1–8.)

LITTLE is known of the Upper Jurassic Fish-fauna from discoveries in British Formations; and though considerable information upon the subject has already been acquired, this has been chiefly obtained from the fine Lithographic Stones of Bavaria, Würtemberg, and France. In these deposits, as is well known, fish-skeletons are found in an almost complete state, with the bones remarkably well preserved; and the only obstacle to the satisfactory determination of the various elements is the extreme compression to which the fossils have been subjected and the hardness of the matrix in which they are enveloped.

Within the last few years, remains of similar fishes have been met with in several localities in the Oxford and Kimmeridge Clays of England; and the soft character of the rock often allows of these fossils being completely disengaged from matrix. Such specimens are of extreme value for the precise determination of certain skeletal features in the genera to which they belong; and it is the object of the present paper to describe an example of *Eurycormus* elucidating some new points in the skeletal anatomy of this genus. The specimen has already been briefly noticed[2] as being the first evidence of the occurrence of the fish in the British Jurassic.

The fossil in question (Pl. X. Figs. 1–8) is a fine example of the skull and adjoining elements discovered by Mr. Henry Keeping in the Kimmeridge Clay of Ely, and makes known, for the first time, the form and proportions of several of the head-bones in *Eurycormus*. The specimen was acquired last year by the Woodwardian Museum, Cambridge, and the writer is indebted to the kindness of Professor McKenny Hughes for the opportunity of investigating its characters.

The occipital border (Fig. 2) forms a straight transverse line, and the width of the cranium at this point is nearly equal to half of its total length. The occipital bones are too much crushed and obscured for

[1] Read before the Geological Society, January 8th, 1890.

[2] Smith Woodward, "Preliminary Notes on some New and Little-known British Jurassic Fishes," Rep. Brit. Assoc., 1889, and Geol. Mag. [3] Vol. VI. (1889), p. 448.

description; the side walls of the brain-case and the otic capsule, though evidently ossified, are also obscure; a small post-frontal (Fig. 1, *pt.f.*) seems to be present; and the only other recognizable cartilage-bone worthy of note is the robust, triangular prefrontal (Fig. 1, *pr. f.*), which constitutes the antero-superior angle of the orbit. The interorbital septum is apparently unossified.

The membrane bones of the cranial roof are much crushed and broken, but portions of the long, narrow parietals (Figs. 1, 2, *pa.*) and frontals (Fig. 1, *f.*) are distinguishable, the former and the posterior half of the latter displaying a superficial tubercular ornament. The parietals extend to the occipital border, and the hinder part of their median suture exhibits a very deep sinuosity (Fig. 2). The precise limits of the parietals and frontals are not shown, owing to the accidental crushing and removal of the middle region of the skull. On either side of the parietals, a large squamosal occurs (Figs. 1, 2, *sq.*), longer than broad, and with a slightly excavated outer border into which fits the upper margin of the superior postorbital: it is superficially marked by a few scattered tubercles and pittings, and a transverse, though inwardly and backwardly inclined groove in the posterior half seems to indicate a sensory canal. On the right side, partly overlapping the anterior extremity of the frontal, is a well-preserved nasal (Fig. 1, *na.*, Fig. 3), longer than broad, with a rounded and somewhat fluted posterior margin, and superficially marked with a few rugosities and tuberculations: at the anterior outer angle of this bone a small narrow smooth process occurs, distinctly notched at its base, especially on the inner side, and thus marking the position of the openings of the olfactory capsule.

The hyomandibular (Fig. 4) is exposed on the left side, much vertically elongated, and with a broad mesial expansion posteriorly; the upper extremity is scarcely expanded, the anterior margin is slightly concave, and a prominent longitudinal ridge occurs upon the anterior half of the outer face of the bone, gradually becoming obliterated above and below. Of the symplectic and quadrate nothing is recognizable, and the only element of the pterygo-palatine arcade identifiable with certainty appears to be a portion of the great, broad metapterygoid on the left side.

The extremity of the snout is broken away, thus exposing small plate-like bones in the anterior part of the roof of the mouth, covered with a cluster of slender, conical teeth (Fig. 8): these are evidently the vomers, and may perhaps also comprise portions of the palatines. The premaxillæ are lost, except a small fragment on the left side, which bears a conical tooth of larger size than those of the inner cluster just mentioned. The maxilla (Fig. 1, *mx.*) is long and slender, laterally compressed, gently arched so that the alveolar margin is convex, and more than twice as deep behind as in front; a robust inwardly-directed process extends from the anterior end of the bone to abut against a portion either of the palatine or vomer; its outer face is rugose, but not tuberculated; and the teeth are arranged in a single close series. In the hinder two-thirds of its length the maxilla is bounded above by a long narrow jugal bone (Fig. 1, *ju.*), abruptly truncated behind but rapidly tapering to a point in front, and with a smooth or only slightly rugose external surface.

The mandible is much crushed and the symphysis lost, but three of the elements are readily distinguishable. A thin, plate-like splenial (Fig. 5, *spl.*) occupies the inner face, and is provided with small teeth. The dentary (Figs. 1, 5, *d.*) is the largest bone and only shows the sockets of a single series of relatively large teeth in the anterior portion of its length: it is relatively deep and seems to have been somewhat bent inwards inferiorly. The hinder border of the dentary exhibits a re-entering angle into which fits the anterior pointed extremity of the well-developed angular bone (Fig. 1, *ag.*); this element being longer than deep, with a thickened, smooth, ginglymoid hinder face (Fig. 6), probably for articulation with the inferior extremity of the preoperculum.

The teeth in both jaws are round in section, relatively long and slender, and may be appropriately described as styliform.

The membrane bones of the cheek are very large and few in number. A single trapezoidal bone, narrower above than below, occupies the greater part of the postorbital region (Fig. 1, $pt.o_1$.); two (or perhaps three) smaller postorbitals bound its inferior margin ($pt.o._{2, 3}$); and there is a trace possibly of a small triangular element at the hinder end of the maxilla and jugal (x). A narrow suborbital bar (*so.*), without distinct sutures, extends along the superior borders of the jugal to a single, large ovoid plate (*ao.*), which occupies the space between the cranial margin and the anterior third of the maxilla. These bones are externally ornamented in part by rugosities, in part by tuberculations.

The sclerotic is ossified, and fragments are seen on the right side (Fig. 1, *scler.*).

The single azygous jugular plate is very large, elongated, and narrow, about two-thirds as long as the mandible; and immediately behind it are the remains of a few stout, narrow branchiostegal rays, on the right side overlapping a fragment of the ceratohyal. The preoperculum is shown on the right side in position (Fig. 1, *p.op.*), very long and narrow and gently arched; and immediately behind is the large, quadrate operculum (*op.*). The suboperculum and interoperculum are unfortunately destroyed, but a fragment of the former is seen on the left side.

A large triangular supratemporal bone (Fig. 1, *st.*) occurs above the operculum, tapering towards its apex at the middle of the occiput. A small supraclavicle (*s. cl.*) and the upper half of the clavicle (*cl.*) are also recognizable.

The vertebræ of *Eurycormus* have already been described by Dr. von Zittel,[1] and it thus suffices merely to note that two examples of the characteristic form (Fig. 7) are seen in the hinder portion of the fossil. The pleurocentra (*pl.*) and hypocentra (*hyp.*) are distinctly separated by the oblique lateral suture; and the inferior element bears a lateral articular facette for a bone of the hæmal arch.

[1] K. A. von Zittel, "Handbuch der Palaeontologie" (1887), p. 230, fig. 242.

On comparing the head of *Eurycormus*, as now described, with that of the recent *Amia*,[1] there will be found to exist the most remarkable similarity, not only in general features, but even in points of detail. The membrane bones are all similar in form and arrangement, and the majority differ little in relative proportions; the dentition is identical; and even in so special and unusual a feature as the direct articulation of the preoperculum with the angular bone the two genera under comparison exactly agree. The genus *Eurycormus* has already been placed in taxonomic works in the same great group as the existing *Amia*; and the new osteological facts detailed above thus tend to confirm the accepted determination.

II.—Note on the Gill-rakers of *Leedsia problematica*—a Gigantic Fish from the Oxford Clay.

By A. Smith Woodward, F.G.S., F.Z.S.

(PLATE X. Figs. 9, 10.)

At the last meeting of the British Association the writer briefly described a remarkable series of bones of a large unknown fish from the Oxford Clay of Peterborough, preserved in the collection of Mr. Alfred N. Leeds, of Eyebury. The name of *Leedsichthys problematicus* was proposed for the genus and species thus indicated; and the systematic position of the fish remained doubtful, owing to the fragmentary character of its skeleton.[2]

No further discoveries of importance have hitherto been made, but an opportunity is now afforded of publishing figures of two imperfect gill-rakers (Pl. X. Figs. 9, 10, 10*a*), which are perhaps the most readily recognized and characteristic elements of the fish in question. As shown in side-view (Figs. 9, 10), each gill-raker is laterally compressed, slightly expanded at the basal extremity, and rarely straight, but irregularly bent or contorted. The surface is coarsely rugose, and one long border is rounded, while the other is cleft by a longitudinal median furrow. The rounded border is comparatively smooth, but the furrowed edge (Fig. 10*a*) is coarsely serrated, a series of short oblique ridges terminating in points on each side.

It has been suggested that the generic name may be conveniently shortened, that of *Leedsia* not being elsewhere occupied. The writer hence proposes to refer to the fish in future as *Leedsia problematica.*

EXPLANATION OF PLATE X.

Fig. 1. *Eurycormus grandis*, A. S. Woodw.; head, lateral aspect, two-thirds nat. size. Kimmeridge Clay, Ely. [Woodwardian Museum, Cambridge.] *ag.* angular. *ao.* antorbital. *cl.* clavicle. *d.* dentary. *f.* frontal. *ju.* jugal. *na.* nasal. *op.* operculum. *p.op.* preoperculum. *pa.* parietal. *pr.f.* prefrontal. *pt.f.* postfrontal. *pt.o* $_{1-3}$. postorbitals. *s.cl.* supraclavicle. *scler.* sclerotic. *so.* suborbital, *sq.* squamosal. *st.* supratemporal. *x.* doubtful bone.

„ 2. ——— hinder portion of cranium, superior aspect.

[1] R. W. Shufeldt, "The Osteology of *Amia calva*," Rep. U.S. Fish Commission, 1883, pp. 747–837, with plates.

[2] Geol. Mag. [3] Vol. VI. (1889), pp. 451–453.

FIG. 3. *Eurycormus grandis*, right nasal bone, outer aspect.
,, 4. ——— left hyomandibular, outer lateral aspect.
,, 5. ——— anterior section of mandibular ramus. *d.* dentary. *spl.* splenial.
,, 6. ——— posterior end-view of right mandibular ramus, showing ginglymoid surface.
,, 7. ——— two anterior vertebræ, lateral aspect. *hyp.* hypocentrum. *pl.* pleurocentrum.
,, 8. ——— front view of dentition of vomers (? and palatines).
,, 9, 10. *Leedsia problematica*, A. S. Woodw.; imperfect gill-rakers, side view. Oxford Clay, Peterborough. [Collection of Alfred N. Leeds, Esq., Eyebury.]
. 10*a*. edge view of part of Fig. 10.

Unless otherwise stated, the Figures are of the natural size.

III.—Notes on the Geology of Finland.

By R. N. Lucas, B.A.

A STAY in Finland of some months' duration (in the summer of 1885) enabled me to make an acquaintance of considerable intimacy with the Archæan rocks of that very interesting district.

Owing to the kindness of two prominent members of the Finnish Geological Survey, Prof. Wiik, who was good enough to place the valuable collections of the Helsingfors University Museum at my disposal, and was constantly ready to give me assistance in every way, and the Hon. A. F. Tigerstedt, with whom I traversed some hundreds of miles of country, I succeeded in amassing a considerable number of observations, which it was at one time my intention to collect together under the above heading. Since forming this intention, however, I had the good fortune to receive the later sheets of the official survey with the accompanying descriptions. I felt that the observations of an individual could in no case possess the value that attaches to an official work of this kind, and I have therefore abandoned my original design. The plan adopted in the following pages has been to replace the observations recorded in my note-book by details drawn from the sheets of the survey. My own observations have merely dictated the general plan, have formed in fact the mould into which the disconnected data drawn from the above-mentioned sources have been poured. Those data themselves have in the main been selected from the survey sheets, and may therefore be regarded as possessing a semi-official stamp.

An attempt has been made to introduce some uniformity into the nomenclature adopted. Thus "gneissoid granite," "granitoid gneiss," "granitoidite," etc., have been replaced by granite-gneiss and gneiss-granite respectively,—terms to which, as will be seen in the sequel, a very *definite* signification is attached; and the confusing term "hälleflinta" has been relegated to that capacious limbo which has already received the "greenstones" and "traps."

I. The Archæan Series.

The architectonic relationships of the fundamental rocks of the country, though extremely complicated when viewed in detail, present when considered *en masse* some general characteristics which may be of use in assisting the reader to comprehend the structure of the region as a whole.

The central lake district, comprised roughly speaking by a polygon drawn through the points Heinola, Tammerfors, Jyvaskylä, Kuopio, and St. Michel, is mainly of eruptive origin, consisting of granites, syenites, etc., of Laurentian age that have pushed their way through the gneisses and schists that surround them, and are very likely to some extent responsible for the tremendous crushing and crumpling which the latter have undergone. The "rapakivi" district of the extreme south, which will be described fully in the sequel, may be regarded as in some sort a continuation of this eruptive area. Round this region are arranged the foliated members of the Archæan series, contorted, folded, reduplicated and turned upside down to any extent, but still in the main striking with considerable regularity, on the west side, N.—S. or N.E.—S.W.; on the east side N.W.—S.E.; and on the south side E.—W. On proceeding to walk outwards, therefore, from this central granitic district, one would successively cross the edges of the Laurentian series, meeting first with the granite-gneiss and then with the younger gneisses and schists, though the exact order in which one would encounter the various members is often confused and inverted by folding or reduplication. In the more eastern districts, Karelen and the country north of Ladoga Lake, one would eventually meet the Huronian, and, further east still, the Taconian series. Of course it is not intended to be understood by this that the eruptive rocks are confined to the districts above indicated, the whole of all these series being much pierced by both acid and basic intrusive rocks, but merely that within this region eruptive rocks predominate. It will thus be seen that the geotectonic structure of Finland is not unlike that of Switzerland during the Triassic period—a low Archæan district—composed centrally in the main of granite and allied rocks, towards its outskirts of gneisses and schists, which are overlain by rocks of comparatively recent geological age. Should Finland ever be raised into a great mountain-chain, which, as the country has for a long time been continually rising, may some day be brought to pass, this central granite area, then enormously compressed, would probably take upon it exactly the appearance and characteristics of the protogene granite of the Central Alps, and the gneisses and other members of crystalline and sedimentary series would be found occupying corresponding situations.

The district to which the following notes principally refer lies to the south of this central granitic region, and comprises consequently the older members of the Archæan series.

It is proposed to divide the subject into two parts, dealing with—I. Foliated and Crystalline Rocks. II. Eruptive Rocks.

Foliated Rocks.

Granite-Gneiss.[1]—This is the name now generally adopted by the Finnish geologists for the lowest and consequently the most

[1] Though placed under the heading "Foliated Rocks" granite-gneiss should more properly be described as "banded."

ancient member of the Archæan series. Wherever it is exposed to view it appears as emerging from beneath younger Laurentian strata which have been deposited directly upon it, or it is covered as far as can be seen conformably by the younger micaceous gneiss into which it passes by insensible degrees. Thus in the neighbourhood of Pääjärvi it is overlain for a considerable distance by hornblende gneiss and eurite, from which it is sharply separated. As a rule it is much pierced by intrusive granite of probably similar age, which has found its way in between the layers of the granite-gneiss, and which, having taken on a parallelism of structure through the influence of lateral pressure, is often on superficial examination hardly to be distinguished from it, and has then received the name of gneiss-granite. The mineralogical composition of granite-gneiss is as a rule extremely uniform, consisting in varying proportions of light grey and grey fatty-looking orthoclase, and white pearly oligoclase, very finely striated grey to white transparent and semi-transparent quartz and black mica. At times a certain amount of red orthoclase mingles with these constituents, causing the rock to assume a reddish colour, and in the neighbourhood of the above-mentioned granite masses it passes over completely into the red oligoclase gneiss-granite.

Microscopic sections of the granite-gneiss of Southern Finland, kindly placed by Prof. Wiik at my disposal during my stay in Helsingfors, were found to display with marked distinctness the peculiarities of granite-gneiss that distinguish it both from ordinary granite and from gneiss-granite. The crystals of quartz and felspar, particularly of the former, are seldom completely developed, but present a rounded appearance, suggestive of crystalline aggregation about originally attrited grains, in this respect resembling strongly the appearance under the microscope of the more crystalline Devonian "grauwackes." The crystals of mica are usually well developed, and do not in any way present peculiarities similar to those of the felspar and quartz crystals. They occasionally give evidence of internal movements within the rock, being broken across, and one or more of the fragments being transported a short distance in a direction parallel to the general banding; but there are no long streams of mica microliths, as is observed in sheared granites, and the quartz and felspar crystals fill in without interruption the space between the mica fragments. This would seem to point to the movements in question having originated during a pasty or semi-pasty condition of the rock, rather than to effects of pressure or shearing stress in a rock perfectly hard and crystalline at the time.

Grey Gneiss.—The grey micaceous gneiss, which forms the next higher member of the series, overlies the older granite-gneiss into which it often gradually passes, as in the neighbourhood of Borgnäs. It has the same general strike as the gneiss-granite, that is to say, roughly speaking, E. and W., though both at times deviate a good deal from this general rule. In its normal condition it consists of black mica, generally white felspar and quartz. It is frequently much cut up and pierced by veins of granite, as for instance in the neighbourhood of Vihtjärvi, where it is so much impregnated with calcite as to effervesce when treated with acid. Not far from Valkjärvi Lake it is bordered by hornblende schists, when it becomes very rich in hornblende, and often contains magnetic iron ore. At times it passes into a fine-grained, dark grey rock resembling a felsitic schist, and occasionally it becomes very micaceous and contains chlorite. Granite veins and dykes often penetrate it to a very great extent, the granite running through the gneiss, the gneiss interbedded with and surrounded by granite; and sometimes large fragments of gneiss have been broken off and enveloped in the eruptive rock, as in the district around Borgo and near Mansikiri, to such a degree that it becomes almost impossible to say whether the rock should be described as granite or gneiss.

A red variety of micaceous gneiss occurs at a few spots, as for instance near Mörskom, where it strikes E. to W., and is very fine-grained, becoming at times euritic, and consists of reddish-brown orthoclase, yellowish-red plagioclase, grey and white quartz and green mica.

Both varieties of micaceous gneiss are at times very rich in garnet, which mineral tends to replace the mica, and they then become red and white garnet-gneiss, as at Nurmijärvi and Koskis, which at times (as near Loji) growing finer in structure passes into garnet-mica-schist.

A graphite-gneiss has also been observed cutting in a narrow band through a hill of granite near Kukilu church.

In contact with granite the gneiss presents a series of phenomena interesting in their irregularity. In some cases it runs along the surface of contact without any indications of being affected by the contiguity of the eruptive rock. At other times, though there is nothing of the nature of transition from one rock to the other, and the line of separation is sharply defined, the gneiss in proximity to the granite becomes much distorted, and then generally appears of finer grain. Often large portions are broken off and imbedded in the granite, and the foliation of these detached portions is then much contorted. This occurs notably in Sibbo Bay on the south coast. A peculiar facies, which is doubtless a contact phenomenon, occurs occasionally in which the felspar individuals are much larger and coarser, and the whole mass becomes porphyritic.

These varying phenomena may in all probability be best explained by the supposition that the gneiss was in some instances deposited directly upon solidified granite, in others it has been subjected to the modifying effects, both mechanical, physical, and chemical, of a lengthened contact with masses of granite in a state of fusion. That this latter state of things prevailed over extensive areas and for a considerable length of time is rendered probable, not only by the phenomena of disruption and contortion caused by the intrusive action of the granite alluded to above, but also by the gradual passage of *grey gneiss into gneiss-granite* not unfrequently observed, as at Nackskog.

Microscopic examination has occasionally brought to light the occurrence of magnesia, mica, and microline (in specimens from Horis and Sukkola).

Hornblende-Gneiss and Eurite.—These rocks, which together form the principal member of the Upper Laurentian series, occur almost always together, alternating with and passing into one another to such an extent as to necessitate their being considered in conjunction. They thus form one stratified system, and occur as in the neighbourhood of Koskis and Hattina, on either side of belts of granite-gneiss, which they overlie, and presumably in some places cover; their strike being almost always parallel to that of the latter formation. All the members of this series, whether containing hornblende or not, present a more or less fine-grained appearance, and the bands of micaceous gneiss which are at times interbedded approach very closely to the structure of eurite, and might appropriately be termed eurite-gneiss. Mineralogically the composition of this latter rock is the same as that of ordinary gneiss, white orthoclase and oligoclase in small, weathered grains with black mica in small shining laminæ, and small white transparent grains of quartz. At times the grain is so close that the rock becomes a true eurite, the separate minerals composing which are only visible under the microscope. It always contains some hornblende, and passes, as the amount of that mineral increases, into a perfect hornblende-gneiss or hornblende-eurite, as the case may be. Iron and arsenical pyrites occur in considerable quantities as accidental constituents. In certain places, however, the hornblende-gneiss appears more independently and less interstratified with the rocks here described. Such is the case to the south of Helsingfors, at Boe, and in Lill Perno Bay near Borgå. Here it often contains a quantity of calcite grains, which by weathering out cause it to acquire a very riddled appearance, and it is much intersected and broken through by granite veins and dykes.

A specimen of the rock from Boe was examined microscopically by Castrén, who says: "The rock principally consists of hornblende and felspar, the latter generally being triclinic. The hornblende forms single grains, which are well shaped and occur as dark and light varieties, and the rock sometimes contains small quantities of a mineral of the pyroxene group. A section of a small crystal of this mineral that, having grown into a hornblende crystal, had fragmentary crystallographic surfaces, showed distinct and less distinct pinakoidal cleavage, and extinguished polarized light in a direction parallel to the plane of cleavage, the plane of the optic axes being normal to the plane of most perfect cleavage. Another section, in which the cleavage planes were parallel, showed an extinction angle of 30°. This points to the crystal being diallage. Prismatic cleavage was not perceptible in the first section, and in it the prism was more developed than the pinakoid. Apatite and derived epidote grains occur as accidental constituents."

Another specimen from Stigsböle was found by Castrén to consist of triclinic felspar and hornblende both of the dark and light green variety, together with quartz and a certain amount of magnesia mica.

As mentioned above, the hornblende-gneiss is frequently intersected by and interbedded with granite to such a degree as to render it difficult to determine which rock is present in the greater quantity. At Mortsjö, one of the many places where this phenomenon occurs, the plainly stratified hornblende-gneiss passes into a fine-grained indistinctly foliated rock, resembling a syenitic granite. We thus have here a case that is in all probability one of a gneiss metamorphosed by contact with a granite of similar age to itself, a fact which certainly speaks strongly in favour of the theory that gneiss was originally deposited as such, and has not received its present constitution *exclusively* through the action of chemical, thermic or mechanical metamorphism.

Mica, Hornblende, and Actinolite Schists occur at many different places, although not in such a manner in the south and west of the country as to entitle them to be considered as constituting a distinct formation. On the contrary, they form comparatively thin bands interbedded with gneiss, into which they often gradually pass. The mica-schist, the passage of which into gneiss is most frequently observed, consists as a rule of black mica and greyish-white quartz. Sometimes, as occurs near Hirvela, thin bands of mica-schist are found alternating with micaceous gneiss, the layers of each rock, however, being sharply separated from each other in such a way as strongly to suggest the sedimentary origin of the whole. More sparingly bands of hornblende-schist have been observed. They consist as a rule principally of hornblende and some black mica, in addition to which red orthoclase and white plagioclase are occasionally though seldom found. The cleavage is generally determined by the mica. The actinolite schists play much the same role as the hornblende schists, which frequently pass into them. Under the microscope they are found to consist in the main of actinolite and quartz, and sometimes contain plagioclase and suggestions of chlorite. Copper ore is frequently to be observed in this rock, and in it occur the celebrated copper deposits of Orijärvi.

Non-Foliated Rocks.

Quartzites and Fibrolite Quartzite.—Quartzites occur in considerable amount throughout the whole district; seldom, however, independently, but generally interbedded with mica-schist, which by gradual loss of mica frequently passes into it. The quartzite at times seems to form a line of separation between the mica-schists and limestone strata, especially in the neighbourhood of diorite schists, as near Orijärvi, in which situations it is often sandstony in appearance and fissile. In Tavastland quartzite occurs on a much more extended scale, forming hills of sufficient size to constitute conspicuous features in the landscape. Thus, near Turismaa, there is a narrow elevation some three miles in length by one mile and a half in breadth, composed entirely of quartzite striking E. and W. Under the microscope this rock was found to consist almost exclusively of quartz, with a thin skin of weathered iron oxide. A light-red mineral—fibrolite—also occurs in small quantities, but is nevertheless present in sufficient amount to give the whole rock a very characteristic appearance.

Pyrargyllite, hornblende, and tourmaline occur as accidental constituents. The fibrolite needles are sometimes clustered together, sometimes arranged radially round a transparent nucleus and usually pierce the quartz. The whole rock has been enormously crushed and sheared, and would seem in every way to resemble closely the quartzite of the "Pfahl" in the Böhmer Wald (described by Gümbel, "Ostbayerische Grenzgebirge"). On its northern side it occurs in contact with a peculiar rock—a kind of quartzite-gneiss or quartzite-breccia, which the microscope shows to be a hornblende-gneiss infiltrated with quartz. It has been thought possible by several geologists that the quartzite of the "Pfahl" may be of eruptive origin. There is much to favour the same opinion being held of the Tavastland quartzite. Among the principal grounds which may be urged in its support, the occurrence of this contact alteration of the surrounding gneiss is certainly of importance.

Crystalline Limestones.—The crystalline limestones interbedded with the gneiss formation are of considerable interest, both from the regularity with which their strike follows that of the gneisses, from the number of accessory minerals which, as is usual with the Laurentian limestones, they contain, and from the very interesting contact phenomena with granite which they display. The rock is generally coarsely crystalline and of a pure white, though at times it passes into a fine-grained yellowish marble, as near Träskby. The accessory constituents most usually found include felspar, augite, serpentine, graphite, pyroxene, malakolite, condrodite, and wollastonite. The latter mineral has been observed near Yttela, where the limestone occurs in contact with eurite-gneiss. Most generally the limestones occur completely surrounded by granite. A typical contact presents the following features:—The limestone is coarsely crystalline, and the surface of contact smooth and irregular in outline; the granite, which is likewise coarse-grained, is covered by a brown talc-like skin, and is completely free from any veins of limestone projecting into it; the skin intervening between the two permits the limestone to be easily pulled apart from the granite. At times a band, some feet thick, of white oligoclase intervenes between granite and limestone, and the granite shows a disposition towards parallelism of arrangement owing to the occurrence of layers of biotite. Near Kaukelmaa occur some small bands of limestone surrounded by and mixed up with greyish eurite destitute of distinct strike—the whole apparently being a fragment uplifted by granite. The coarsely crystalline structure of the limestone in proximity to the granite (as above described) renders the opinion tenable and even probable that the latter rock has been deposited from hot springs which have found their way up through clefts in the granite from below. Limestones of a similar kind are also found in conjunction with pegmatite in veins penetrating gneiss.

(*To be continued.*)

IV.—On *Rhynchopygus Woodi*, Forbes sp., from the English Pliocene.

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

ECHINARACHNIUS WOODI was founded by Forbes in his "Monograph of the Echinodermata of the British Tertiaries"[1] on two fragments from the Red Crag of Suffolk; of all the species described in that work, this has been regarded as the most interesting and problematical. As this species certainly belonged to a genus now foreign to the British or European seas, it was felt, that if its correct generic position could be determined, it and *Temnechinus* would indicate the true affinities of the Crag Echinoderm fauna, better than the cosmopolitan genera with which they were associated.

The material on which the species was based was, however, so imperfect that Forbes prefaced his description by the remark, "It is with much doubt that I refer the following fossils to this genus," while he further admitted that it was not impossible that the two fragments might belong to different species. Though subsequent echinologists have expressed doubts as to the correctness of Forbes's identification, they have accepted it provisionally, and on the strength of it, *Echinarachnius* has been generally recorded as a Pliocene genus; otherwise it has only been found fossil in the Pleistocene deposits of Japan and Patagonia.

In spite of the fact that the diligent collectors of Crag fossils had been stimulated by Prof. Forbes' exhortation to seek for even the smallest fragments of this species, nothing was found that would elucidate its true systematic position. The first advance was made by Prof. A. Agassiz in his report on the Echinoidea collected by the Challenger:[2] from the evidence afforded by Forbes' figures he therein suggested that, while the more perfect specimen was probably part of either a *Rhynchopygus* or a very flat *Nucleolites*, the other (fig. 6*b*) belonged to a Pourtalesian, as "it has the peculiar snout thus far known only in that group."

Prominent attention was thus directed to the specimen as, had this view been correct, the fragment would have been the sole fossil representative of the Pourtalesiadæ. Prof. F. Jeffrey Bell, at the request of Prof. Svén Lovén, made a careful examination of the specimens, which had then been acquired by the British Museum, but concluded that they were too imperfect for any definite decision as to their affinities to be made. Professors Lovén and Bell however both agree that "there seems to be no reason whatever for regarding it as having been part of something like a Pourtalesia."[3]

While recently examining the collection of W. J. Lewis Abbott, Esq., F.G.S., I found another fragment of the species, and as this shows the structure of the anal area, it enables its generic position

[1] Palæontograph. Soc. 1852, pp. 12, 13, pl. ii. figs. 5 and 6.
[2] "Challenger" Reports, Zool. vol. iii. No. 1, p. 30, 1881.
[3] S. Lovén, "On *Pourtalesia*, a Genus of Echinoidea," Kongl. Svenska Vetensk. Akad. Handl. new ser. vol. xix. No. 7, p. 86, 1883.

to be conclusively settled. Mr. Abbott has generously presented his specimen to the British Museum (Nat. Hist.).

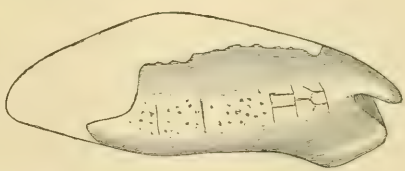
From the three specimens now known a tolerably complete specific diagnosis can be compiled. Prof. Forbes' larger specimen shows the anterior end with most of the anterior and right antero-lateral ambulacra, a long sweep on the right side, and the peristome. Mr. Abbott's specimen is the posterior end of an individual of about the same size as the former, and it shows the projection in the second figure which Prof. Agassiz regarded as the snout of a Pourtalesian, to be the supra-anal rostrum of a *Rhynchopygus.* I am glad thus to be able to demonstrate the correctness of Prof. A. Agassiz's shrewd suggestion in regard to the larger of the fragments figured by Forbes.

Prof. Forbes' reason for referring these specimens to *Echinarachnius* is not at all apparent. This genus had been well diagnosed by Agassiz and Desor,[1] a few years before Forbes wrote, and his own specimens differed from this in nearly every particular. The absence of actinal furrows, jaws, internal pillars and partitions; the presence of phyllodes; the equality of the ambulacra, the tumidity of the ambitus, and the excentricity of the peristome, together form a combination of characters which necessitate the removal of the species from *Echinarachnius* to a genus of a different order, viz. from the Clypeastroida to the Spatangoidea. The marked floscelle shows that it belongs to the Cassidulidæ, and the transverse anus and supra-anal rostrum prove that it belongs to the genus *Rhynchopygus.*

The following specific diagnosis is based on the larger of the specimens figured by Forbes and on that found by Mr. Abbott; the smaller of the original specimens may possibly belong to a distinct species, as it is somewhat more tumid at the ambitus.

Rhynchopygus Woodi (Forbes), 1852.

Outline seen from above elliptical, broadest at a quarter of the length from the posterior end; the supra-anal rostrum forms a conspicuous projection on the posterior margin. In elevation the species is seen to be depressed, with the apex at the anterior third: the anterior margin is sharper than the somewhat tumid lateral margin. The posterior extremity is rendered apparently vertical owing to the projection of the rostrum.



The apical disc is situated at the vertex.

Ambulacra subpetaloid, and open below: flush with the test: pores distant.

Actinal surface concave anteriorly, but bulging posteriorly.

[1] Catalogue Raisonné des Echinides, Ann. Sci. Nat. Zool. (3) vol. vii. p. 133, 1847.

Mouth anterior: situated in the deeper part of the depression. Floscelle well marked.

Periproct wide and forming a deep concavity in the posterior margin: it is protected above by the prominent supra-anal rostrum.

Tubercles small in impressed areolæ: generally uniform, but largest along the actinal area.

Dimensions—Calculated from Prof. Forbes' type (fig. 5).

Length ...	... ...	48 mm.
Width: at apical disc ...	... ...	34 ,,
,, maximum	... ...	40 ,,
Height...	... ...	15 ,,

Distribution—Coralline Crag, Layston Road Pit, Aldborough [Brit. Mus. E. 3207]. Red Crag: Bullock Yard Pit?[1] The locality of the type specimens is doubtful. Forbes mentions none, but Morris[2] attributes the species to Suffolk. The condition of the specimens and matrix suggests Walton-on-the-Naze.

Affinities of the Species—The genus *Rhynchopygus* dates from the Cretaceous; from the species of this system and from the Eocene, viz. *R. marmini* (Desmoul.)[3] of the Maestrichtien; *R. pygmæus*, Dunc. and Slad.,[4] and *R. calderi* (d'Arch. and H.[5]), from the Ranikot and Khirthar series; *R. navillei*, Lor.,[6] *R. thebensis*, Lor., and *R. zitteli*, Lor.,[7] from the Egyptian Eocene,—*R. Woodi* may be readily distinguished by the greater development of the supra-anal rostrum. In this species it extends back as far as the end of the test, whereas in the above forms it occurs but as a more or less slight prominence, on the posterior slope. *R. siutensis*, Lor.,[7] also from Egypt, differs in its thicker margins and less conical abactinal surface. The remaining species of the genus, as at present limited, are two existing American forms, and with these *R. Woodi* is more nearly allied; *R, pacificus* (A. Ag.)[8] has a more central apical disc and a different general shape, the posterior side being more sloping and there is no lateral tapering towards the anterior. *R. caribbæarum* (Lam.),[9] found also in the Pleistocene of Guadeloupe is the closest ally of *R. Woodi*, and here again the greater prominence of the supra-anal rostrum in the latter forms a ready means of distinguishing them.

The affinity of *Rhynchopygus Woodi* to the two species last

[1] A. and R. Bell, "On the English Crags," Proc. Geol. Assoc. London, vol. ii. 1872, p. 197.

[2] Morris, Cat. Brit. Foss. 2nd ed. 1854, p. 78.

[3] Desmoulins, Etudes sur les Echinides, 1837, p. 360.

[4] Duncan and Sladen, The Fossil Echinoidea of W. Scinde, Pal. Indica. ser. xiv. vol. i. (3) fasc. ii. 1882, pp. 68–9, pl. xv. figs. 5, 6.

[5] D'Archiac and Haime, Description des animaux fossiles du groupe nummulitique de l'Inde, t. i. p. 352, pl. xxx. fig. 19. Paris, 1853.

[6] De Loriol, Monographie des Echinides contenus dans les couches nummulitiques de l'Egypte, Mém. Soc. phys. et d'hist. nat. Genève, vol. xxvii. i. p. 85–8, pl. iv. figs. 2–4.

[7] De Loriol, Eocaene Echinoideen aus Aegypten und der libyschen Wüste, Palæontographica, vol. xxx. (3) pp. 18, 19, pl. ii. figs. 9–12.

[8] Al. Agassiz, "List of the Echinoderms sent to different Institutions with Annotations," Bull. Mus. Comp. Zool. vol. i. No. 2, p. 27, 1863.

[9] Lamarck, Hist. nat. anim. S. Vert, p. 349, 1801.

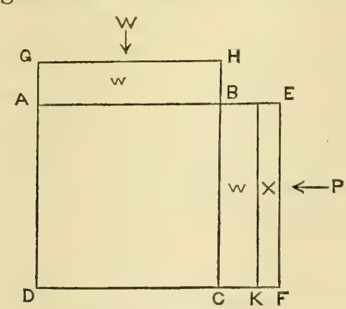
referred to is of interest as it serves to strengthen the resemblance of the English Pliocene Echinoidea to those of the West Indian area. The close connection between the echinoid faunas of the Tertiary deposits of the Antilles and of the Mediterranean subregions has been frequently insisted upon, notably by Prof. Al. Agassiz.[1] Hence the resemblances noted by Forbes between the Crag species and those now living in the Mediterranean do not diminish the more intimate connection of the former with the present West Indian fauna.

As far as can be judged from our present knowledge of the recent and fossil distribution of *Rhynchopygus*, it lived in the seas of the Palæarctic region from the Cretaceous to the Pliocene; about the latter period it migrated westward, for *R. Woodi* is apparently the last European representative, and it does not seem to have been recorded from the rich faunas of the West Indian Miocene. It now survives only round the shores of the Mexican and Antillean subregions of the Neotropical region. The genus is in fact confined to the littoral zone of a tropical sea, and it is difficult to see how it could have crossed the deep and cold abysses of the Atlantic. Hence either the European Miocene and Pliocene Echinoidea must have migrated westward along a belt of the continental zone that then stretched across the temperate regions of the Atlantic; or, the Echinoid fauna of the West Indies and the European later Tertiaries must have both originated from one that occupied an area of comparatively shallow sea somewhere in the North or Central Atlantic.

V.—On Dynamo-Metamorphism.

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

I HAVE derived much help towards understanding Mr. Harker's instructive letter upon the above subject from making the following simple geometrical construction.



Suppose $A\ B\ C\ D$ to be the section of a cube of the contorted rock.

For simplicity we may suppose that the contorting pressure P has been met by a fixed abutment at $A\ D$. Suppose that in the process the mass $B\ C\ F\ E$ has been forced past $B\ C$, and that the result

[1] "Challenger," Rep. Zool. vol. ii. p. 30.

has been that a quantity $G\ A\ B\ H$ of rock has been forced up to a height w above its original level $A\ B$.

Divide the distance between $B\ C$ and $D\ F$ into w and x; w being equal to the height w, to which $A\ B$ has been lifted. Let W be the weight of the "cover." Then the work done by P upon the original mass of material has been $P\ (w + x)$; and the work done by the material in raising the cover has been $W w$. Their difference is the work expended upon the mass $G\ D\ C\ H$, and it is $P\ (w + x) - W\ w$; or, $work = (P - W)\ w + P x$.

Now since the volume $B\ G$ equals the volume $B\ K$, it is obvious that the volume $K\ E$ has disappeared during the compression. Hence, $P x$ expresses the work of condensation. Consequently $(P - W)\ w$ must express the work of shearing expended upon the rock.

We must now inquire into what forms of energy the work has been converted. And first of the work of shearing.

This is converted,

(1) Into the potential energy implied in the raising of the centre of gravity of the mass through a height $\frac{1}{2}\ w$.

(2) It is employed in bending and breaking the rock, and overcoming friction. Since this part of the energy is not reconvertible into mechanical work, it must take the molecular forms of heat and chemical action, the effects being most concentrated where the mechanical action has been greatest.

The work of condensation $P x$ goes wholly to increase the results of (2); but the distribution of the effects will be more uniform than of those caused by the shearing.

To estimate the effect of the "cover" we observe that, as the cover is increased, W is increased, and of course P must also be increased, because it will require a greater force to lift a greater mass of overlying rock. But if instead of rock we had a liquid mass, we see that if P would lift W, $P + Z$ would equally lift $W + Z$, while, although the two pressures are equally increased, their difference remains the same. It seems probable, therefore, that, if the rigidity of the rock were to remain unaltered, $P - W$ would not be affected by a change in the quantity of cover. Hence, the work of a given amount of shearing expended upon the mass will not be affected by the amount of cover, except in so far as additional pressure increases, by closeness, the rigidity and frictional resistance of the substance, and so, when W is increased, requires P to increase at a more rapid rate than W. This appears to be a reason why dynamo-metamorphism may be greater at greater depths.

Mr. Harker seems to be of opinion, "since energy not lost by conduction must be absorbed in the production of mineralogical changes," that, where there is little hindrance to conduction, such changes will be smaller. But this conclusion does not follow unless heat longer retained is rendered conducive to mineralogical chemical reactions by the consequent increase of temperature. Appropriate elevation of temperature will no doubt help to promote chemical reactions. But in so doing does the heat disappear as heat?

In the case of a freezing mixture I suppose it does so, but such a case would not occur among minerals. Some geologists think that dynamo-metamorphism takes place *viâ* heat; but I am inclined to think that the energy developed by the work upon the rocks takes at once the form of chemical energy, without passing through the intermediate stage of heat. I should like to hear what is thought on this question by those who know.

In the case of the Bude rocks, and of the similar series at Tenby, I suppose that the movement took place at the same time as that of the disturbance of the Carboniferous rocks of the West of England. The Poikilitic series, which is the next in sequence, has not partaken of this disturbance. Hence, it is possible that the "cover" at the time of the disturbance was not great, and this will go some way to account for the small amount of metamorphism observed by General McMahon. Perhaps, also, the argillaceous beds may have acted as lubricants, and diminished the friction, thus reducing the magnitude of the force $P - W$, and the corresponding work expended on the rocks.

Harlton, Cambridge.

VI.—Note on a Pliocene Mammalian Fauna at Olivola in the Upper Val di Magra (Prov. Massa-Carrara), Italy.

By C. J. Forsyth Major, M.D.

FOSSIL Mammalian remains from Olivola were already known in the last century. Giovanni Targioni Tozzetti describes and figures several bones from that locality, which he refers to some species of *Trichechus* or *Phoca*, but which, as far as the figures permit of a judgment, belonged to Ruminants.[1] In this century, the deposit was mentioned by Pareto,[2] and by Cocchi,[3] who from stratigraphical considerations ascribe it to the Pleistocene.

A few remains from this locality, collected by Prof. Cocchi and Prof. Capellini, are preserved in the museums of Pisa and Florence, and in that of Bologna. Rütimeyer has made known an imperfect skull of an Antelope (*Palæoryx Meneghinii*, Rütim.) from Olivola, preserved in the Pisa Museum.[4] He, too, divides the opinion of the before-mentioned Italian geologists as to the geological age of the deposit, which he calls an Ossiferous Breccia. As, however, the skull of Antelope in which he recognizes a type from Pikermi, points to an older horizon, he supposes it to have been floated into this "Breccia" from an older deposit.

[1] Giovanni Targioni Tozzetti, Relazione d'alcuni Viaggi fatti in diverse parti della Toscana, ed. seconda, t. x. 1777, pp. 386–395, tav. i.

[2] L. Pareto, Note sur les subdivisions que l'on pourrait établir dans les terrains tertiaires de l'Apennin septentrional (Bull. Soc. Géol. de France, 2e série, t. 22. (Séance du 20 févr. 1865).

[3] I. Cocchi, L'Uomo fossile nell' Italia Centrale, Studi Palænotologici (Mem. Soc. Ital. Scienze Natur. vol. iii.), Milano, 1867, pp. 34–36.

[4] L. Rütimeyer, Die Rinder der Tertiaer-Epoche, nebst Vorstudien zu einer natürl. Geschichte der Antilopen (Abhh. Schweiz. Palæont. Gesellsch.), vol. iv. Zurich, 1877, 1878, fasc. vii. figs. 13, 14, pp. 86, 87.

An upper jaw of *Equus* from this same deposit, preserved in the Museum of Pisa, has been described by me as *Equus Stenonis*, Cocchi. On that occasion I gave my reasons for retaining it as of Pliocene age, relying on the few mammalian remains known at that time.[1]

During the autumn and beginning of winter of 1889, I had an opportunity of undertaking some excavations at Olivola, which brought to light a rich Mammalian fauna of undoubtedly Pliocene age, that is, contemporaneous with the Val d'Arno fauna. I was prevented through illness from terminating the work; but the results already obtained are deserving of mention, as besides some quite new forms of Antelope, up to this day fifteen species have been discovered, most of which are components of the Val d'Arno fauna, and are represented partly by much more complete remains than even the rich Florentine Museum can boast of.

Carnivora.—The genera *Felis*, *Machairodus*, *Hyæna*, *Canis*, *Ursus* are represented. The remains of *Felis* (two crania, two lower jaws and several leg bones) belong to a large form which may be provisionally referred to the *Felis arvernensis*, Cr. et Job.

Machairodus.—Several upper canine teeth of *M. cultridens*, Cuv., and a nearly complete hinder leg.

The remains of *Hyæna* belong to the larger Val d'Arno form, named by Weithofer *H. robusta*; right and left maxilla of a young individual, with the milk dentition still in situ; several lower jaws, and various bones.

The remains of *Canis* are very numerous, and partly in a fine state of preservation. Several skulls and nearly all the parts of the skeleton have been secured. The majority of these remains belong to the species described by the present writer under the name of *Canis etruscus*; but there is a larger form too, which may prove to belong to *Canis Falconeri*, Major, incompletely known at present.

The *Ursus etruscus*, Cuv., which, as well as all the other forenamed Carnivora, has not hitherto occurred frequently in the Val d'Arno, is well represented at Olivola by an incomplete skull, various upper and numerous lower jaws, besides bones of the skeleton.

Rhinoceros etruscus, Falc.—A complete cranium, with adhering mandibula, several other crania, less complete, several mandibulæ, and numerous other remains.

Equus Stenonis, Cocchi.—Two crania; mandibulæ; numerous bones.

Mastodon arvernensis, Cr. et Job., is for the present represented only by the proximal parts of a cubitus and radius.

Sus Strozzii, Menegh.—A skull and various mandibulæ. A lower canine tooth of *Sus* from Olivola, deposited many years ago in the Museum of Pisa by Prof. Cocchi, was declared by Rütimeyer[2] to be indistinguishable from the corresponding canines of the living *Sus scrofa*. A comparison, however, with the lower canines of living

[1] Forsyth Major, Beitraege zur Geschichte der fossilen Pferde insbesondere Italiens, IIter Theil. (Abhh. Schweiz. palæontol. Gesellsch. vol. vii. 1880, pp. 124, 125, Taf. iv.).

[2] *loc. cit.* p. 86.

and Pliocene species shows it to agree exactly with the latter, the outer plate of enamel being as large from behind forwards as the inner, as is the case also in the Siwalik species, and in the living *Sus celebensis*, Müll. & Schleg., and *Sus verrucosus*, Müll. & Schleg., from Java, whilst in *Sus scrofa* the outer side is very narrow from behind forwards. The more complete remains of *Sus* found last year at Olivola have placed beyond doubt their identification with *Sus Strozzii* from the Val d'Arno.

Ruminantia.—Numerous pieces: skulls, jaws and other parts of the skeleton of at least three forms of *Cervus*, the largest of which, in the form of the antlers, comes very near to *Cervus dicranius*, Nesti. The other cervine remains have not yet been satisfactorily identified with known Pliocene species, their preparation not being as yet advanced enough.

Of *Bovine* animals the deposit has yielded several crania of a hornless form; one incomplete cranium provided with horns; besides numerous other parts of the skeleton.

Since Prof. Rütimeyer examined the remains of bovine Ruminants from the Val d'Arno deposited in the Florentine Museum, several valuable pieces have been added to that collection. These, together with the skulls discovered at Olivola, have been lately re-examined by me, and the result is that I in some respects disagree with Rütimeyer's views on the subject. It will be remembered that Rütimeyer placed the hornless crania of the Val d'Arno in the genus *Leptobos* (*Leptob. Strozzii*, Rütim.), represented in the Siwaliks by horned and hornless (female?) crania of the *Leptobos Falconeri*, Rütim., and in the Pleistocene of the Narbada Valley by a hornless cranium, named *Leptobos Fraseri*, Rütim.[1] For my part, I cannot discover any differences between the crania of "*Leptobos Strozzii*" and "*Bos etruscus*," besides those which are the consequences of the presence or absence of horn-cores. The same opinion was expressed by me many years ago, when I declared the hornless skull in the Florentine Museum a mere variety of "*Bos etruscus*," suggesting that it was probably the female form.[2]

As, moreover, the differences between the horned crania of *Leptobos Falconeri*, Rütim., on the one hand, and of *Bos etruscus*, Falc., on the other, which have induced Rütimeyer to place the first in his group of the *Portacina*, the second in the *Bibovina*, are not marked enough in my opinion, there being several transitional forms in the various known crania of *Leptobos Falconeri*, as well as in those of "*Bos etruscus*," the only way of resolving the question seems to me to include all the known remains of bovine animals of the Italian and French Pliocene in the genus *Leptobos*. The synonymy of the only species therefore runs as follows:—

LEPTOBOS ELATUS (Croizet sp.).

1828. *Bos elatus*, Croizet, Coll. Mus. Paris.
1854. *Bos elatus* and *Bos elaphus*, Pomel, Catalogue Méthodique.

[1] L. Rütimeyer, Die Rinder der Tertiaer-Epoche, etc., p. 157, seqq.
[2] Forsyth Major, Nagerüberreste aus Bohnerzen Süddeutschlands und der Schweiz. Palæontographica, ii. 2 (xxii.), 1874, p. 123.

1859. *Bos etruscus?* Falconer MS., cf. Palæontological Memoirs and Notes, ii. p. 481.
1866. *Bos* (*Bibos*) *etruscus*, Rütimeyer, Versuch einer natürl. Geschichte des Rindes, etc. ii. p. 71, seqq.
1874. *Bos etruscus*, Forsyth Major, Nagerüberreste aus Bohnerzen Süddeutschlands und der Schweiz, Palæontographica, ii. 2 (xxii.), p. 123.
1877–8. *Bos* (*Bibos*) *etruscus*, Rütimeyer, Die Rinder der Tertiaer-Epoche, Abhh. Schweiz, Palæont. Ges. p. 154.
1877–8. *Leptobos Strozzii*, Rütimeyer, *ib.*, pp. 167, 168, 173, 175.
1884. *Bos elatus*, Depéret, Nouvelles études sur les Ruminants pliocènes et quaternaires d'Auvergne (Bull. Soc. Géol. de France 3e série, t. xii. p. 247).
1885. *Bos elatus*, Lydekker, Catalogue of the Fossil Mammalia in the British Museum (Nat. Hist.), part ii. p. 19.

The *Rodentia* are for the present represented only by a large incisor, referable to the genus *Castor*.

VII.—On the Base of the Sedimentary Series in England and Wales.

By the Rev. Prof. J. F. Blake, M.A., F.G.S.

As Dr. Callaway has asked in a recent Number of the Geological Magazine[1] for the grounds on which I suggest that some of the volcanic rocks of Shropshire may perhaps be classed as Cambrian, I take this opportunity for bringing before your readers the present state of the inquiry into the nature and classification of the earliest sedimentary rocks in this country. This inquiry has been spoken of by Dr. Callaway as the "Archæan controversy"; but we must not necessarily call everything that is earlier than the Cambrian "Archæan," any more than in old days it was right to call everything Precarboniferous "unfossiliferous greywacké"; nor should the inquiry be considered a controversy in its present stage, but rather a search for more accurate knowledge.

Omitting the Charnwood Forest rocks, and the Caldecott ashes, about which there is little definite to say, the areas in which Precambrian rocks have been described are—1. St. Davids; 2. Anglesey; 3. North-west Carnarvonshire; 4. Malvern; 5. Shropshire; 6. Devonshire and Cornwall. I propose to point out, according to my view, our present state of knowledge, and the history of its growth, in each of these localities.

1. *St. Davids District.*—It appears that when this was mapped by Prof. Ramsay, before 1857, he recognized below the basal Cambrian conglomerates, besides a mass of crystalline rock, a series of more or less volcanic detritus and lavas, but that this recognition was never published. In its place was the indication that the latter were "altered Cambrian." In 1877, however, Dr. Hicks, considering that the Cambrian conglomerates, from the nature of their contents, and their apparent unconformity, indicated a greater break than had been recognized by Prof. Ramsay, set to work to describe the underlying rocks as distinct formations. He was also under the influence of theories of metamorphism; but whereas, in Prof. Ramsay's hands, these theories had led him to consider lavas and ashes as the

[1] Geol. Mag. Decade III. Vol. VII. p. 143, 1890.

altered representatives of ordinary sediments, in Dr. Hicks's, the crystalline masses were considered as stratified rocks whose bedding had been almost or entirely obliterated. In his original paper (1877) he stated that the "Dimetian series, near St. Davids, are chiefly quartz-schists, chloritic schists, indurated shales," while at Porthlisky "the quartzose beds are less altered," and "we find massive beds of calcareous shale and chloritic schists, and associated with them also dolomitic limestone beds several feet in thickness." The series was stated to have a constant strike to the south-east, and to be 15,000 feet at least in thickness—a very definite description. The "Pebidian" had a strike nearly at right angles to this, and "consist chiefly of indurated shales, often porcellanitic in character," while "the lower beds, resting immediately on the Dimetian axis, are hard compact conglomerates chiefly composed of masses of quartz and altered shale, or such masses as might have been derived from the underlying rocks," and on the west side the appearance of the rocks is much like that at St. Davids, but there is a larger proportion of greenish and purplish schists alternating with the compact porcellanite shales, "so that there is every probability we have a repetition of the whole series," and "on the S.W. of Ramsey Island the beds are compact porcellanites like those near St. Davids, and the bedding is also easily traced."

Such was the original description—in which it will be noticed that there was not a single word about granitoid rocks, quartz felsites (except as a dyke), agglomerates, or volcanic ashes.

In the following year, however (1878), he had gone over the ground again in company with Mr. Hudleston and Prof. Hughes, and it is not too much to say that in all essential features, the lithological description of the rocks were entirely altered, so that it is not difficult to say *who*, rediscovered, so to speak, the volcanic series. Now we hear that the Dimetian consists of "quartz porphyries, fine-grained quartz-felsites, ashy shale-like rocks (which turn out to be altered basalts), compact granitic-looking rock, quartziferous breccias, granitoid quartz schists somewhat chloritic, schistose bands which are also basalts, and crystalline limestone bands." Thus the quartz schists turn out to be for the most part granitic-looking rocks and quartz porphyries, the indurated shales are basalt dykes, and the dolomite beds several feet in thickness are calcareous infiltrations along joints. It will be noted also that the quartz porpyhries and felsites are placed at the base of the series. It is still maintained, however, that the whole is bedded. Passing to the Pebidian, we now hear of agglomerates at the base, felspathic breccias, indurated ashes, volcanic tuffs, conglomeratic and ashy beds, a thick band of felstone, probably a contemporaneous lava, and bright green ashes, in addition to the porcellanites, schists, and conglomerates, which alone made up the series before. Moreover, the beds on the west are not now repetitions of those on the east, but higher in the series, while the mass in Ramsey Island, instead of being a bedded porcellanite, consists of felstone, felstone porphyry, hornstone, and felspathic breccias. It is scarcely possible to imagine a more complete change of description. We are now told that "the general likeness in the whole series to a group of volcanic rocks found in more recent strata is most marked, especially to those associated with the Lower Silurian," a remark which never could have been made at the close of the *former* description. Almost the only statements that remain the same are that the Dimetian is bedded, and that the Cambrian conglomerates "almost invariably for the most part consist of the fragments of the rocks on which they lie."

After such a change as this it is important to remark that the conclusion Mr. Hudleston arrived at was that the "Dimetian" represented the hypogene condition of a group of which the "Pebidian" was the surface product—a conclusion which negatived any bedding in the former, or any great difference in age between it and the latter.

A year later Dr. Hicks visited the district east of St. Davids, and examined the rocks at Roche and Treffgarn, which Murchison had previously described as felstones, intrusive into the Cambrian rocks amongst which they occur, but which Dr. Hicks described as bedded, and accepted Mr. Davies's name of Halleflinta. For this he created a new group, the "Arvonian," and referred to it the quartz porpyhries of St. Davids, which the year before he placed at the base of the Dimetian, but now placed above it and unconformable to it, without giving any definite reason for the change.

Dr. Geikie's examination of the district in 1883 gave a new complexion to the whole matter. He showed that the whole of the "Dimetian," as last restricted, was nothing but a granite throughout, and stated also that it was intrusive into the Cambrian. In the first of these conclusions he was supported by Prof. Renard, and by all subsequent observers, as he had practically already been by Mr. Hudleston, but the supposed evidence of the second point has not been considered sufficient for its proof. The quartz porphyries which had been called "Arvonian" he considered as apophyses of the granite; and as regards the "Pebidian," while accepting the *later* petrological descriptions of Dr. Hicks, he minimized the separation between this and the Cambrian conglomerate, and challenged Dr. Hicks to prove his statement that the latter is chiefly composed of "fragments of the rock on which it lies." This Dr. Hicks has never been able to do, seeing that the most marked feature of the conglomerate is that it is *not* composed of such fragments; instead of doing so, he now attempts to show that the matrix might have been derived from granitoid rocks.

My own observations, while coinciding with the general ideas of Dr. Geikie, and differing chiefly on the question of how far the granite intrudes, led me to think the gap between Cambrian and Pebidian a wider one than he admits. Recently Prof. Lloyd Morgan, going over the same ground, brings them closer together again.

As to the "Arvonian" in its typical locality, I have shown that the supposed bedded halleflinta at Roche is nothing but a silicified andesite, and this determination has been accepted by Prof. Bonney and others and thus—exit Arvonian.

With regard then to the St. Davids district, the net result of past researches amounts to this. There are below the Cambrian conglomerates a series of bedded rocks, partly of volcanic and partly of sedimentary origin. Associated with these there is a mass of granite which is bounded in many places by quartz porphyrites. The granite is not actually seen to intrude into anything, but the quartz porphyries may be either its apophyses, or a later eruption which is more or less intrusive into both it and the volcanic ashes. The whole of this group is distinct in character from the Cambrian rocks which succeed (with insignificant exceptions), and there is an interval of time between them; but of what amount, or of what importance, this interval may be, is at present an open question, probably not to be settled without introducing considerations derived from other areas. All this does not seem to be more than might have been made out by a good geologist working for a fortnight on the ground, but the labour that has been spent will not have been thrown away, if we are taught caution in the use of theories of metamorphism from the utter failure of even geologists of credit to make out bedding in massive crystalline rocks which we might as soon expect to discover as the original stratification of an earthy iron ore in a bar of pig iron made from it.

To the series thus determined—whether it be a subdivision of the Cambrian or a portion of an anterior system of rocks—the "local name" of Pebidian rightly belongs. The use of the same word for any minor group in other areas depends on a more accurate correlation than has yet been accomplished.

2. *Anglesey.*—In his earliest classificatory paper, Prof. Sedgwick placed the older rocks of this island in his Lower Cambrian group, making what is now known as Cambrian proper his Middle Cambrian, while our Ordovician rocks were his Upper Cambrian. In later writings, however, he excluded the Anglesey rocks from the Cambrian, which he then made to commence with the "Llanberis slates." In deference, however, as it seems, to the views of the Geological Survey, he left it an open question whether the Anglesey rocks might not be altered representatives of some part of his Cambrian system, though it is obvious that he did not of his own accord consider them as such. With regard to the opinion of Prof. Ramsay that all the older rocks of Anglesey were metamorphosed representatives of the Cambrian, we need not imagine that he supposed they were the very same beds as are seen on the mainland continued into the island in an altered state, but that he found no line of demarcation between them, and no necessity to consider them of a different system, but rather as a downward extension of the Cambrians which were here entirely metamorphosed. Such appears also to have been Sedgwick's original opinion when he called them "Lower Cambrian." And such for many years, in deference to the deservedly respected teaching of Prof. Ramsay, they were held to be. As soon, however, as attention began to be turned to possible Precambrian rocks, Anglesey was naturally thought of. Accordingly, in 1878, Dr. Hicks examined the junction of the granite at Llanfaelog with the

overlying conglomerates, and found that the latter was made out of the fragments of the former. In the same way Prof. Hughes, near Llanerchymedd, and Mr. Roberts at Penlon and Nebo, found conglomerates at the base of the so-called "Silurian." From the running of the line of junction on the Survey map, and the conspicuous character of the conglomerates along this line, it is obvious that these facts were perfectly familiar to Prof. Ramsay. Why then did he not, like Dr. Hicks and Prof. Hughes, consider them to prove the Precambrian age of the granite and associated rocks? The answer is obvious. He mapped the conglomerates not as Cambrian but as Silurian; and the evidence on which he did this is equally plain. The only fossils ever obtained in the rocks which lie conformably above the conglomerates are such as need not be older than the Arenig. It is true that at Llanfaelog there is a good quantity of grit between the fossils and the conglomerate; but this is not the case elsewhere, and we do not know whether there are any strike faults here or not. It is therefore an entirely ungrounded assumption that the conglomerates are basal Cambrian, in the sense that they underlie the diminished representatives of Menevian, Lingula Flags, and Llanberis slates. Dr. Hicks has therefore in no way proved that the rocks are Precambrian, or brought the slightest evidence against the conclusions of Prof. Ramsay. The first real evidence of this kind is that supplied by Dr. Callaway. By his description of the rocks and demonstration of their great complexity and thickness, he rendered it obvious that so distinct and vast a group could not be a mere downward extension of any other group, but must be worthy of a place apart. If any place apart is assigned to it, this must be below the Cambrian.

But unless we can show an unconformity between these and the true base of the Cambrian, the separation remains a matter of appreciation only. Fortunately the very spots where Prof. Ramsay read continuity, by being better exposed now prove unconformity. Thus on the east of the island near Beaumaris, Prof. Bonney has shown that, the lower rocks, which are continuous across the island, and of the same general character as the rest, are either overlaid by, or are faulted against, a peculiar group of stratified rocks largely composed of volcanic materials, and by tracing it further I have shown that the junction is a real unconformity. Now these upper rocks are continued into the mainland, and there we learn by stratigraphy that they cannot possibly be younger than basal Cambrian in the most extreme sense of the word. From whence it follows that the underlying rocks are really Precambrian. It may be taken therefore as settled that the main mass of the schistose slaty and associated rocks of Anglesey belong to a period which antedates the Cambrian. This proved, three questions still remain, is this true of all of them? do they form one system or several? and can any part of them be correlated with the rocks of St. Davids?

In answer to the first question, Prof. Hughes has pointed out that in the Northern district the beds have a uniform dip to the north, and near the summit of the series, as thus ascertained, there occurs a fossiliferous band containing *Orthides*, of which the most characteristic is *Orthis Bayleana*. Prof. Hughes's own solution of the difficulty thus arising appears to be that this is here a continuous upward sequence from the Arenig slates which occur in the centre of the island. This ignores the great fault by which the two are separated, according to every other observer. The only other solutions at present suggested are either that the fossiliferous bands are faulted in, or that the fossils are really characteristic of the Precambrian series. Against the former solution is the fact that the containing rocks are just like the rest for some distance north and south, and that no fault which should have the required effect can be seen, even by careful observation directed to this very object, in the adjacent clear coast sections. The only recognized faults in the neighbourhood let down narrow troughs of dark shales with Llandeilo Graptolites, which are therefore younger than the surrounding mass, and not older as they should be if the latter were of Bala age. Still, if the third solution be not accepted, the next most probable one would be the existence of some disturbance not as yet properly understood. The third solution, that the fossils found are characteristic of Precambrian rocks, seems too startling at first to be entertained at all—*Orthis* in Precambrians! Nevertheless there is something to be said on this point. The principal and in fact only definitely recognizable species is a very well marked one, and in spite of the abundant fauna of North Wales it has never been seen there, in any other locality. I have compared it with the type which comes from near Wexford, and there cannot be the slightest doubt that it is the same species, *Orthis Bayleana*. I have been to Wexford to try to learn its true position. But I never saw such a jumble of rocks as are there exposed; it is perfectly hopeless to learn anything of their position. But two things I learned, first, that this species nowhere occurs in the true slaty Ordovicians, which are not many miles away, and that the matrix is quite different. It is said to be associated with recognizable Trilobites, but these again occur in an entirely different matrix.

In answer to the second question—whether these rocks form one system or several—Dr. Hicks replies by implication that there are three, since in certain spots he thinks to recognize his Dimetian, Arvonian, and Pebidian. By the proof, however, which I have abundantly given, and which is for the most part now accepted, that the granite referred to the Dimetian is an intrusive rock, these reduce to two; but as no detailed observations bearing on the question have been published by this author, there is no occasion to discuss whether the remaining divisions represent real groups.

But Dr. Callaway's description is directly to this point. According to him there are two distinct groups, the "gneissic" and the "slaty." The evidence adduced in support of this is threefold. 1. That one of the "slaty" rocks contains fragments of a "gneissic" rock. 2. That at one spot a rock referred to the slaty group contains fragments of a granite referred to the gneissic group. 3. That the lower group is much more altered than the upper. He affirms also that the two groups are always brought together by faults. Two of these proofs depend upon the detailed examination of isolated spots or rocks, and after having fully examined them, I have elsewhere given full reasons why they cannot be considered satisfactory. With regard to the third reason, it is generally true that the lower part is more gneissic than the upper, but this alone will scarcely be considered sufficient to establish the independence of two groups; nor does the author appear to lay great stress on this, but merely uses the terms as distinctive descriptive titles.

My own researches, which have been pretty exhaustive in every area, with the exception perhaps of the granitic portion in the centre, have shown that the gneissic portion is often slaty, and the slaty portion often gneissic; that the faults by which they are supposed to be separated cannot in most cases be traced in the field; and that there is so intimate a connection throughout between one part and another that they cannot be separated into two systems, though a more or less arbitrary line may be drawn between the upper and lower portion. Taken altogether they form so vast and complicated a system, as first shown by Dr. Callaway, and later by my own more detailed examination (which has led me also to include the rocks of Howth Hill and Bray Head in the same series), as to be comparable in extent and variety of forms, not with one zone of the Cambrian, but with the whole; and they are equally worthy with it, or with the Silurian, of distinct recognition, notwithstanding that it is at the present moment doubtful how far they are fossiliferous. It is for this reason that I call the whole the Monian system. It is more than probable that this, like every other system, may be usefully divided into several subordinate members, possessing distinct characters; and it is with such subordinate members that any of the groups elsewhere established amongst Precambrian rocks will have to be correlated, if they really correspond. I scarcely feel sure, however, that any such correspondence has as yet been made out, whatever may be the case in the future. Even so, however, the Monian system is no rival to any other group, being more comprehensive than any. It has been objected to this system that it has neither bottom nor top. As to the bottom, this can only be definitely fixed by finding a lower system still. At present it is the lowest system in the area, and the earth is its bottom; and if any other is found, it will probably be somewhere in the Highlands of Scotland—but not in Wales. As to the top, in Anglesey itself this is defined by the unconformable Cambrian, but the fact of this unconformity shows that there may be higher parts of it elsewhere. Such a higher part, for instance, I reckon the Bray Head rocks to be, which are separated from Anglesey only by the breadth of the Irish Channel. It has also been objected that if it is distinct from the Pebidian, it becomes equivalent to the crystalline schists, and as such requires no new name. This, however, is to misunderstand its nature; it is only partly schistose, and the special peculiarity of it is that it unites in one sequence true crystalline schists with ordinary sedimentary rocks.

When we come to the details of the development, new questions arise. With regard to the upper part, my own description, if somewhat fuller, agrees essentially with that of Dr. Callaway; but with the lower part this is not so. Dr. Callaway laid down a scheme of succession as follows, beginning at the base:—1. Halleflinta; 2. Quartz schists; 3. Grey gneiss; 4. Dark schist; 5. Granitoidite; every one of which were regarded by him as altered stratified deposits. This sequence is naturally objected to by Dr. Hicks as inconsistent with his own identifications. According to my own observations, the halleflinta is of no stratigraphical importance, the granitoidite is an intrusive granite, and under the term "dark schists" have been included two distinct groups of rocks, the truly stratified chloritic schists, and the finely foliated hornblende schists. Eliminating these, the remaining sequence between quartz schists, grey gneiss and chloritic schist, agrees very closely with my own arrangement. Dr. Callaway, however, has now come under the influence of the theory that foliation is produced by dynamical metamorphism, and this leads him to say that his "time succession" no longer holds. How far the above arrangement is withdrawn is not, however, quite clear. The character of the granite and halleflinta has nothing to do with this theory, since neither are foliated. In the case of the hornblende schist, the stratigraphical evidence of its sporadic development and its intrusive character have shown that it is a truly igneous rock which may once have been a dolerite; but the same evidence is entirely wanting in the case of the chloritic schist and grey gneiss, some of which latter Dr. Callaway now regards as an altered felsite.

The third question relates to the possible correlation of parts of this series with rocks elsewhere described. The intrusive granite has been called Dimetian. It may or may not be of the same age as the granite of St. Davids; the only connection between them is that both antedate the Ordovician, and both are granites. The "Halleflinta" has been called Arvonian; but the "Halleflinta" in Anglesey has no resemblance and no analogous position to any rock at St. Davids or in Pembrokeshire; the only connection between any two such is that both have been called by the same wrong name, neither being typical halleflintas. All the rest of the older rocks of the island were at one time called Pebidian by Dr. Hicks; they cannot *all* be, and nothing is more certain than that they are all distinct from the Bangor beds of Prof. Hughes, which have also been called Pebidian. Prof. Bonney, in his British Association address, clearly distinguished the two, and stated that the Anglesey rocks were older than those of Bangor, which latter he referred to the Pebidian. I myself originally referred the volcanic portion of the Monian to the Pebidian, and called it the "St. Davids group,"—a correlation dependent only on the facts that both are of volcanic origin, and both in some sense Precambrian; but the rashness of such a correlation is already clear. At the present moment, therefore, none of the Precambrian or Monian rocks of Anglesey have been definitely identified with any rocks elsewhere.

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

VIII.—Notes on the Probable Origin of Some Slates.

By W. Maynard Hutchings.

(*Concluded from page* 273.)

IN the deposits previously described what takes place appears to be about as follows. The larger flakes of biotite undergo an alteration which largely produces epidote, and not improbably granular rutile, though this is not at all proved. *Crystals* of rutile very rarely result during the process. Such of the iron of the biotite as is not combined in the epidote (which is strongly coloured) is removed in solution, some of it being deposited again as limonite diffused throughout the deposit, and some taking part in the formation of the thin bands of ironstone, being precipitated as carbonate.

Saline solutions dissolve and carry away part of the silica; finally the whole of the constituents of the mineral are broken up, partly removed in solution, or diffused among the other materials of the deposit. Of the titanic acid contained much is probably removed in solution jointly with the silica, and this dissolved titanic acid may most likely, as Thürach suggests is the case in some sandstones and other sedimentary rocks, supply by re-precipitation (by means of carbonic acid or otherwise) and crystallization, the material for the secondary crystals of anatase. It may also, diffused through the mass, take part with the titanic acid of the smaller fragments of biotite in yielding the countless small crystals of rutile; and we may very reasonably ascribe to it partly also the formation of the thin plates of micaceous ilmenite.

The flakes of muscovite of anything like noticeable size do not appear to undergo any sort of change, so far as these particular deposits are concerned.

The small, and very small, flakes and shreds of biotite appear to undergo an alteration which differs in many ways from that suffered by the larger bits, and which seems to depend not merely on ordinary attack by water and by saline solutions, but to be also, and more largely, brought about by chemical inter-action between the biotite and other minute materials with which it is deposited in intimate contact. This fine mixture of biotite, muscovite, kaoline, the minutest waste of felspar,[1] and in less degree of quartz, and probably other substances, under the joint action of pressure, warmth, and mineral solutions, gives rise to various decompositions and re-

[1] The experiments of Daubrée (Geologie expérimentale, 1879) on the effects of the mutual attrition of fragments of granite in water, are of very great interest and bear strongly on the special point here in question. It is to be particularly noted that he shows how comparatively rapidly the *felspar* is reduced to the condition of the finest mud ("limon"); and further, that the felspathic mud so produced has not been simply reduced mechanically to powder, but has been *chemically* acted upon to a noticeable extent in a relatively short time. The felspar has given up some of its alkali to the water and has become hydrated by taking water into combination. The granite used in these experiments was fresh and its felspar not weathered.

This fine mud of hydrated felspar, so fine as to remain suspended in water several days, and depositing as a plastic mass, is in just the condition for rapidly undergoing chemical changes and acting powerfully upon the minute fragments of biotite, etc., with which it is intimately intermingled.

combinations, which result, among other things, in the formation of new mica, with the separation of titanic acid in the form of rutile.

Into these reactions, whatever may be their exact course, even the muscovite in very fine state of division appears to enter; and there is good reason to conclude that in fine-grained sediments of suitable composition, exposed long enough to the necessary conditions as to pressure, temperature and percolation of solutions, an almost complete regeneration of the "paste" to mica can and does take place, and that this regenerated material, under intenser dynamo-metamorphic action, is converted into some of the forms of micaceous slates known to us.

The mica so formed is probably what in its more advanced stages of development is often known as "sericite." This is usually stated to be only a special form of muscovite, but the term is really rather vague. Rosenbusch points out that some of the "sericites" of the phyllites show strikingly small optic-axial angles, and that probably more than one substance is included in the term. This would follow naturally from the mode of origin seen in these clays and shales, the proportions of the various ingredients of the deposits being liable to vary considerably. We are still very ignorant as to the exact composition of the micas, and the relationships of their optical and chemical properties.

Whether we call this newly-formed micaceous mineral sericite,[1] or leave it nameless, we may take it to be highly hydrated, and it seems justifiable to assume that it contains magnesia as part of its constitution. In these fireclays, though no trace of biotite may be visible to the most careful microscopic search, magnesia is nearly always present, and usually to an extent which would answer to a considerable percentage of biotite of the kind usual in granites.

Thus, in a list of analyses quoted by Percy, magnesia ranges up to 1·21 per cent., and a fair average may be given as about 0·75 per cent. For a comparison we may place this against analyses of granite, taking for instance those given of British granites by Teall (British Petrography), where the maximum of magnesia is 2·48 per cent., the Skiddaw granite containing 1·08 per cent. One fire-clay examined by me, with no trace of visible biotite, contained, by most exact determination, 0·95 per cent magnesia.

If we now come to consider some of the older slates,—the roofing-slates of Wales and Cornwall,—it seems that much of what we have been able to observe in progress in the clays and soft shales of the Coal-measures finds considerable application, and throws light on some important points. Thus, not one of these slates which I have studied contains any trace of original biotite; and most of the Welsh, and all the Cornish (from Tintagel, Delabole and district) contain varying, and mostly large, amounts of rutile, in just the same form and mode of dissemination as the fireclays.

[1] Although "sericite" is now stated to be only a form of muscovite, and the use of the term is open to some objections, it will still be well to follow Rénard, who elects to continue its employment when writing of mica having the special physical characters which it shows in the class of rocks now under discussion.

Both the questions—why never any biotite, if we are supposed to have in these slates only consolidated and cleaved original deposits?—and whence all the evenly diffused rutile?[1]—appeared to me to need explanation till I examined less advanced stages of presumably similar deposits.

In many Welsh slates epidote is abundant, and in some of them just such clusters of plates are seen as I have above described. In others it is more often in larger, more solid lumps. We might expect great pressure to frequently solidify such groups of plates and grains; and of course epidote may be present from other sources than original biotite.

The base and main constituent of all these slates is a small-grained mica, mostly lying flat in the plane of cleavage of the rock.

I do not think it would be going beyond what is warranted if we were to conclude that markedly rutiliferous slates had resulted from deposits originally containing much biotite; that slates showing these platy pieces of epidote had formerly contained good large flakes of biotite; while slates containing little or no epidote, no coarse-grained quartz, felspar, etc., but rich in rutile, were formed from such fine deposits as we see in the finest of the fireclays. Again, slates with but very little or no rutile may have resulted from deposits free, or almost free, from biotite; but when grains of quartz, etc., indicate that the deposit was more or less coarse-grained, it is still possible that biotite was present in large flakes, which, as we saw, do not give rise to rutile directly; and if epidote were seen in the forms described, this supposition would receive considerable support.

The other things seen in the clays and shales are still to be found in the slates; the small plates of micaceous ilmenite (sometimes here in perfect hexagonal form), the numerous crystals of tourmaline, etc., etc.

Many of the Welsh slates are much more ferruginous than any of the fireclays, whether by original deposit or subsequent infiltration, and this ferric constituent, under dynamic action, has resulted in the countless transparent red scales of specular iron which give the colour to the various red, purple, etc., slates. Others are as free from iron as any fireclay of the Coal-measures, and all the Cornish slates are remarkably free from it.

A large part of the Welsh slates contains numerous original quartz-grains of various sizes, and felspar may be still recognized in some cases, fresh enough to give the optic figures. Small grains, both of quartz and felspar, are seen in some slates to be blending away into the surrounding mass.

[1] We are indebted to Rénard ("Recherches sur la composition et la structure des phyllades Ardennais," Bulletin du musée royal d'histoire naturelle de Belgique, 1882–1883), for a series of very careful analyses of phyllites, many of which very closely resemble those of North Cornwall.

In ten analyses the titanic acid present varies from 2·28 p.c. to 0·13 p.c., the average being 1·20 p.c.

In the same analyses magnesia ranges from 2·35 p.c. to 1·13 p.c. Combined water is mostly between 3 and 4 p.c., the maximum (unusual) being 4·94 p.c.

In no slate from Tintagel district have I detected a single grain of original quartz, nor any felspar. Secondary quartz is not uncommon, and all cracks are filled with veins of it. Even where no sign of it is seen with the microscope, analysis shows that more silica is present than could be accounted for in the mica, etc. Thus one such sample from Tintagel quarry contained 50·3 per cent. of silica, showing that an excess of that substance is diffused in some form among the other components.

These Cornish slates appear to have undergone far more dynamic metamorphism than the Welsh, and we should expect the obliteration of original grains of the deposit to have been more complete. From the almost total absence of epidote from the typical slates of Tintagel and Delabole, the smallness of the zircons (the one remnant of original deposit), and the large amount of rutile, I would infer that they were laid down as a very fine silt indeed, of granitic origin mainly.

In all these slates, Welsh or Cornish, however, the proportion and the size of the other constituents may vary, the fundamental base of mica is much the same in nature so far as can be made out with the microscope alone. I am unable to ascertain that any of the roofing-slates contain any residue which could be identified with the granular, impure "kaolinitic" material of the clays and shales. All this is apparently altered, the processes seen in progress in those earlier stages of metamorphism having been completed under the much longer and more intense dynamic action which the slates have undergone, clastic muscovite having also nearly totally disappeared.

This action has resulted, among other things, in dehydration, the combined water in slates being very much less than in shales and clays, however micaceous these may be. This combined water ranges about 4 to 5 per cent. in slates. It is often double and more in fireclays and shales.

So far as I am aware, we are not in possession of any exact knowledge as to the chemical constitution of the mica forming the base of the slates, and it would not be easy to obtain, owing to the difficulty of isolating any of this mica. We have an immense mass of analyses of "clay-slates" in bulk, and magnesia figures in nearly all of them. Thus, in 80 analyses discussed by Bischof (Chemische und physikalische Geologie), it ranges from a trace to 11·71 per cent. This maximum is quite exceptional, a good average would be from about 0·7 to between 2 and 3 per cent. Many slates contain chlorite, which may account for the magnesia in some cases, but many do not contain that mineral, or only very slightly. That magnesia is present—that the materials for biotite are contained in the slates—is shown also by the plentiful formation of that mineral, which is such a usual accompaniment of contact metamorphism, and which also often takes place in advanced dynamic metamorphism. I have not seen this dynamo-metamorphic biotite in any of my Welsh specimens, but it is strongly developed in some of the Cornish, and slightly in many. It is interesting to see, in among the biotite and quartz of contact-slates, the abundant rutile-needles of the original slates (*e.g.* Shap, Skiddaw).

It may be noted that the chlorite which is so plentiful in some Welsh slates, and in most of the Cornish roofing-slates and allied material, appears to be wholly of later date than the rutiliferous sericitic mica, and in many cases to be due to subsequent deposit from infiltrations, such chlorite never showing any inclosed rutile, ilmenite, etc.

In other cases, however, it appears to be due to the more advanced stages of dynamic action, being then intergrown or twinned with muscovite, vertical or more or less highly inclined to the cleavage of the slate. In this manner of occurrence it sometimes contains rutile, and notably so in some Tintagel rocks.

The white mica which is formed with or without chlorite (or with ottrelite at Tintagel) lying otherwise than with the cleavage, appears to be true muscovite. It is present in some Welsh slates, absent from others, and very abundant in nearly all the Cornish slates, being always rich in inclosed rutile. It can all be seen to be due to later stages of dynamic action than that which arranged the main mass of the mica in one plane.

It may be well to bear in mind that though opinion is now mainly in favour of the belief that the mica of such slates as we have been considering is mainly or wholly secondary, and produced *in situ*, there is one very great authority on the subject who arrived at a quite opposite conclusion after much research.[1] Dr. Sorby, in his address

[1] At about the same date as Dr. Sorby's address, Pfaff published a paper on some more recent clay-slates ("Petrographische Untersuchungen über die eocänen Thonschiefer der Glarner Alpen," Sitzungsbericht der K. Bayer. Akad. der Wissenschaften, 1880). The examination of these slates and shales showed a "surprising amount of resemblance to the Palæozoic clay-slates" down to the presence of the "clay-slate needles." Pfaff arrives at the same conclusion as does Sorby as to the slates being simply compacted original sediments; but while Sorby seems to have formed this opinion from the study of the slates simply, and from some reasoning as to what might be looked for as a result of disintegration of granites and other rocks, Pfaff bases his verdict more on the fact that he has studied *clays* of various ages (including Carboniferous, Triassic, Jurassic, and Tertiary), in all of which he sees the microlites (rutile) and the micaceous base, as in the slates.

If the result of a full study of clays and shales were to convince the observer that the rutile, etc., and the micaceous base are all *original* deposit, then the very great similarity in these respects of clays and slates would go far to compel the adoption of the same conclusions as are advocated by Sorby and Pfaff.

As shown above, the key lies in the selection for study of clays whose exact and *direct* origin can be pretty clearly demonstrated. In such clays I do not consider it is possible, in view of all the characteristics, to look on the rutile, tourmaline, mica, etc., as of clastic origin.

Pfaff's paper is abstracted and criticized by Rosenbusch (Neues Jahrbuch für Min. etc., 1881), who expresses very decidedly contrary opinions to those of Pfaff, stating that he holds the *cardinal point* as to the question of the formation of slates to lie in the large amount of mica, from which he concludes that chemical processes have played a large part. "Gewiss wurde das Material zu den Thonschiefern mechanisch herbeigeführt, der Mineralbestand aber der vorwiegend glimmerhaltigen und felspathfreien Abtheilung derselben ist gewiss durch metamorphe Processe bedingt."

In dealing with the same question on a previous occasion (Die Steiger Schiefer, as President of the Geological Society in 1880 (Q.J.G.S. vol. xxxvi.) stated that, though he had at first looked upon this mica as secondary, he was finally of opinion that the main micaceous constituent of the Welsh slates—the mass of small flakes lying parallel to the cleavage —is not secondary, but is simply the compacted material of the original deposit. Dr. Sorby stated that he considered that the mica of granites, etc., "except in special cases, where much iron is present," is not liable to fall to pieces by weathering so as to yield the small flakes seen in slates. He looks upon this small mica as derived from fine-grained micaceous felsites, whereas "coarse-grained granites and felspathic felsites, even when very micaceous, could yield only kaolinitic clays."

"Deposits mainly composed of inert substances like quartz, mica, and kaoline, can undergo little further change," though he considers that felspar may decompose after deposit, giving rise to quartz and opal. He admits that the crystals of mica which are not parallel to the cleavage, "but lie at all possible azimuths," are of new formation, but says that as regards the rest of it "the whole structure is, in fact, just such as would result from the deposition of material sorted by gentle currents and subsequently compressed, vertically by pressure of overlying strata, or laterally by that which gave rise to slaty cleavage."

Dr. Sorby does not lay any stress on the remarkable diffusion of rutile crystals in so many slates; indeed, in the paper above quoted, he does not do more than indirectly allude to them. At the time he wrote the paper, the nature of the minuter "clay-slate needles" as rutile was only just about being established.[1] Had he taken the rutile into consideration, it is difficult to see how he would have explained in such cases its presence in simply compacted original mica from felsites, as the mica of these rocks does not usually contain rutile.

I think the opinion that the mica of granites would not yield a fine-grained deposit is not borne out by the study of the clays and shales of granitic origin; coarse-grained and fine-grained layers of

1877, pp. 116–118), though he was very positive as to the non-admissibility of the clastic origin of the rutiles, tourmalines, etc., of the slates, he was much more reserved in any expression of opinion as to the mica.

Rénard also, who has so deeply studied the slates of the Ardennes, appears to have arrived at views quite opposed to the idea of such rocks being simply compacted original sediments (*op. cit.*).

[1] The first decided proof that these needles are rutile was given by Cathrein ("Ein Beitrag zur Kenntniss der Wildschönauer Schiefer und der Thonschiefernädelchen," Neues Jahrbuch für Min. Geologie, etc., 1881).

In dealing with his method of isolation of the rutile, Cathrein mentions the "roundish grains" as well as crystals, and looks on these as "partly imperfectly developed rutile needles."

Very soon after Cathrein's paper, in the same year, an article appeared in the "Neues Jahrbuch" by Dr. Sauer ("Rutil als mikroskopischer Gemengtheil in der Gneiss- und Glimmerformation, sowie als Thonschiefernädelchen in der Phyllitformation"), in which the proof of the nature of the slate-needles is again fully carried out; and a note by Prof. Rosenbusch states that Sauer had communicated the contents of this article to him in private correspondence before the appearance of Cathrein's paper.

all thicknesses alternate abruptly or gradually, according as the conditions of deposit changed, in so many beds which had the same origin throughout so far as we can see.

I hope I have also succeeded in showing that deposits of the waste of granitic rocks by no means consist of inert substances that could not readily undergo further change, but that, on the contrary, they are very active indeed in such changes.

It must be borne in mind, as Dr. Sorby points out, that it is more than likely that in many slates we have the result of deposits from more than one source of material at the same time; also that they may be produced from *different* sources without such mixture. Further, that the exact nature of slates is liable to vary very considerably even in adjacent laminæ, or in the same laminæ at different parts, so that care must be taken not to draw too decided conclusions from one or two observations.

In considering the nature of the mica, it is to be recollected that some of these slates probably contain more or less of the waste of still older slates of similar nature, which waste would mainly consist of rutiliferous mica. Flakes of white, or almost white mica, with the rutile inclosures, form a prominent constituent of some silts and muds now being deposited, and of some surface clays. This, however, would not much affect the question of the *first* origin of the rutiliferous mica, and we may reasonably suppose that in the early geological periods, to which the slates now specially under discussion belong, there would be less and less probability of previous slates supplying part of the material. Of course, if my contention is correct, that many of the slates resulted from alteration of sediments from granite, more or less rich in biotite, and that these sediments were exactly similar in nature, and underwent just the same processes of change as we can see in the deposits of the Coal-measures, it is not in any way suggested that the *conditions* of deposit were the same. These may have varied to any extent as to depth of water, currents, etc., etc., but the conditions of denudation would be more or less the same, and also the nature of the finally deposited sediment.

Shales, slates, and sandstones pass into one another by all degrees of transition. Many sandstones, especially those of fine grain, have as "cement" the same material which forms the "paste" in the clays and shales above described, and frequently between the grains of quartz we see films of just the same micaceous and rutiliferous alteration-product. Mr. J. A. Phillips (Q.J.G.S. vol. xxxvii.) seems to have observed this in some cases. Thus he says (May Hill Sandstone) that the grains are "cemented together by a turbid siliceous cement, suggesting the idea of its having been deposited from water holding clay in suspension"; and again (Sandstone from Brigham in Cumberland) he speaks of this cloudy cement and says, "Between the fragments of this rock there are sometimes minute crystals of a mineral which may be epidote."

REVIEWS.

I.—Le rocce eruttive dell' Eocene superiore nell' Apennino. By Prof. de Carlo Stefani. Boll. Soc. geol. Ital. VIII. No. 2, 1889.

THE Eocene eruptive rocks of Northern Italy have already acquired a somewhat extensive literature. The last addition to this is the above-cited memoir, which fully sustains its author's reputation for viewing petrological subjects from an advanced standpoint. The memoir is therefore of value, not only as a contribution to the study of some local rocks, but as a pronouncement on the part of a leading Italian geologist on some of the broader geological problems connected with them. English geologists especially will be interested in the expression of such views as "it is wrong to give distinct names to rocks in their altered conditions" (p. 262), or that "from the point of view of lithology, it may be affirmed, in contradiction to the teaching of my masters, that the ancient eruptive rocks are identical with the modern" (p. 262). Prof. Stefani has previously expressed similar views, but they have probably never before been so definitely asserted by any Italian geologist.

The memoir commences with a useful bibliography, and is divided into nine sections. The first deals with the nature, mode of origin, and correlation of the beds with which the igneous rocks are associated: a full list of fossils is quoted, and a short sketch given of the work by which the old view of the submarine volcanic age of the deposits has been disproved. The author maintains instead that they are really normal deep-sea deposits.

The igneous rocks are described in the next five sections; their origin discussed in the seventh; the eighth and ninth are devoted to their stratigraphical relations and distribution, and a summary of the author's opinions concludes the memoir.

§ 2. *The Peridotites.*—The most important of these is a mixture of olivine and enstatite, for which Wadsworth's name of saxonite, though admittedly a misnomer, is preferred to the later name of "harzburgite" (Rosenbusch). The occasional presence of diallage as at Levanto (Bonney), and at Pria Borgheise (Mattirolo), indicates an approach to lherzolite; but the author regards the diallage in these cases as always accessory, and hence declines to accept the rocks as true lherzolites, though Rosenbusch has so named the rock of the latter locality. In other cases the presence of augite suggests a passage to picrite (of Rosenbusch), while in places the scarcity of enstatite leaves the rock as a kind of "dunite." The author denies the occurrence of "wehrlite" on Monte Prato.

The serpentines have always, according to Prof. Stefani, resulted from the alteration of saxonite. In supporting this conclusion he dismisses the following hypotheses of the formation of serpentine: (1) from argillaceous schist, advanced by Achiardi in 1874, a view based on superficial resemblances; (2) from diallage, as urged by Berwerth for that of Rosignano, in consequence of his having mistaken the bastite and enstatite for diallage; (3) from enstatite or other pyroxene in cases where there seems no trace of olivine (Cossa); (4) a theory attributed to (but already promptly repudiated by) Mazzuoli of the formation of olivine, etc., by the dehydration of serpentine. Finally, the author does not regard as reliable the method proposed by Hussak for distinguishing serpentines formed from rhombic pyroxenes from those formed from olivine (p. 196).

§ 3. *The Gabbro.*—This term is adopted instead of euphotide, which has been much used by Italian geologists owing to the misapplication of the former by Savi. A petrosilex or forellenstein is formed locally by the segregation of the labradorite, and a diallagite by that of the pyroxene. The gabbro is also at places altered to "thulite" by the loss of silica and addition of magnesia. There are many alteration products present, including some serpentine; but this the author regards as indicating that the rock was there an olivine gabbro, rather than the formation of the serpentine from diallage.

Norites have been quoted from the district only owing to the diallage having been mistaken for hypersthene.

§ 4. Diabase is extremely abundant; amygdaloidal and variolitic structures are common; in opposition to the opinion of Rosenbusch, Gumbel, etc., the author does not regard the latter as a mere contact phenomenon. True diorite does not occur, but the uralitization of the augite is often so complete that it is then almost impossible, as at Riparbella, to be certain that the rock is really an epidiorite.

§ 5. A soda granite is fairly widely distributed in Emilio and Liguria di Levante, and this Prof. Stefani regards as having probably been a liparite.

§ 6. Certain diabases and serpentine breccias have been previously described, as *e.g.* by Prof. Bonney from Levanto. These the author regards as "tuffs" analogous to those that accompany the "kimberleyite" of S. Africa, and the picrites of the Fichtelgebirge. Sometimes, as Mulino di Villa, the tuffs include diabase fragments with variolitic surfaces; Prof. Stefani regards these crusts as due to the decomposition of the diabase, though it may be suggested that they are really variolitic tuffs like those simultaneously described from Mont Genèvre. Similarly the rock from Levanto, re-described as an "ophicalcite tuff," seems very much like the rock from Mont Genèvre, regarded as a serpentine breccia.

§ 7. In discussing the eruptive origin of the rocks, the author lays much stress on the salbands, which he regards as conclusive in the case of the diabase. Much value is also attributed to the amygdaloidal and porphyritic structures. The other theories, such as Mazzuoli and Issel's "anfimorphic" hypothesis (that the serpentines have resulted from the alteration of a hot, submarine mud), and Taramelli's view of the formation of the same rock as a precipitate in a hot sea, are examined and dismissed. Prof. Stefani claims that all the rocks are eruptive, and that the coarseness of grain of the gabbro is due to its having arisen as an outpouring on the floor of a deep ocean and having solidified under the enormous pressure of the superincumbent water. He further compares the rocks with those of other ages, from the prepalæozoic downward, and is very emphatic as to the impossibility of using age as a character in any natural or logical classification.

§ 8. The relations of the rocks to the sedimentary deposits. Prof. Stefani proved in 1876 that the serpentine of Garfagna was regularly interstratified in the Upper Eocene; this has been supported by Taramelli, and may be regarded as a type case. Sterry Hunt's view that the serpentines are part of a prepalæozic floor exposed at places by denudation, etc., is very summarily dismissed: "It is the opinion of one, who either does not observe facts or, who having observed them, gives more weight to his own conceits than to these." The author has discussed this hypothesis once before, and does not seem to deem it necessary to repeat the process.

§ 9. The most important point established in the section on distribution is that there is as a rule a fairly constant succession; the peridotites were the earliest, the gabbros followed, and the diabases concluded the series. But in places diabase occurs intercalated in either the peridotite or gabbro, and these with other exceptions show that the rule is not absolute.

In conclusion, the author refers to the extension of similar eruptive rocks of the same age, along the northern coast of the Mediterranean; these can be traced in Spain, Switzerland, Dalmatia, and through Bosnia and Herzegovina, as far south as Eubœa. The opinion is advanced that in late Eocene times, these rocks were erupted from a series of volcanoes, often submarine, that encircled the northern margin of a very deep sea, just as the Malayasian volcanoes extend along the northern margin of a deep part of the Pacific.

Though many geologists will probably require further evidence before accepting some of the author's conclusions, such as that the division into plutonic and volcanic is fundamentally erroneous, that the gabbros are eruptive, or that the "serpentine breccias" are "tuffs," they cannot but be grateful to Prof. Stefani for so valuable a contribution to so interesting a group of rocks, and will await with interest the promised publication of the issues of his further investigations. J. W. G.

II.—The Genesis of the Arietidæ. By Professor Alpheus Hyatt. Smithsonian Contributions to Knowledge, 673. 4to. pages vii–xi, 1–223; 14 Plates and 35 Woodcuts. (Washington, 1889.)

THE handling of a collection rich not only in species but in all possible varieties and abnormal forms, and access to the literature upon the subject, are important factors in genealogic investigations. Such opportunities has Prof. Hyatt enjoyed, and his latest work just to hand is another proof that he has turned them to the best possible account.

Since 1867 Prof. Hyatt has given to the world a most valuable series of pamphlets concerning the genealogy and classification of

Jurassic Ammonites, as well as of Cephalopoda generally; and the important and valuable monograph now before us treats not only of the genesis, but also of the entire specific evolution of the grand Liassic Ammonite family, the Arietidæ. Not the least important feature of the work is that it is illustrated by fourteen excellent plates prepared expressly to show the developmental changes and the genealogy of the various species.

The principles of Ammonite development, which, we believe, owe to Prof. Hyatt their first enunciation and application, though they have also been put forward by other workers independently, are, in the present work, fully discussed in two long chapters. "Genealogy" and the "Genesis of Characteristics" are treated in two other chapters; on "Geological and Faunal Relations" is the title of a chapter discussing the birthplaces and migrations of the different series; and then lastly follows a chapter describing the genera and species.

With the main results of Prof. Hyatt's labours we find ourselves in complete accord; but we might be inclined to criticize some of his genealogic conclusions. We are, however, disposed to be cautious in this matter, as we have not the number of specimens to appeal to.

Still it seems to us that to trace the Arietidæ to *Psiloceras planorbe* may be a mistake. This species we regard—on account of the ribs in the inner whorls and its slightly more involute form—as a smooth development of *Am. Johnstoni*, and not the ancestor thereof. That *Am. Johnstoni* and the Arietidæ were derived from a very evolute, perfectly smooth form, and that this was derived from an involute, gibbous-whorled, smooth form—a shell more evolute than *Nannites fugax* and more involute than *Agassiceras lævigatum*, something like *N. fugax* being the ancestor producing forms similar to *Ag. lævigatum* and *Am. miserabile* as it became more and more evolute—seems to be indicated by the inner whorls of species which we have broken up.

However, space does not allow us to discuss this and certain other points; but we wish to say that this work has given us extreme pleasure, and that we cordially congratulate the talented author upon the splendid results which this monograph lays before us—results which indicate a vast amount of careful and critical research. Not only is a study of this monograph absolutely essential to the student of Ammonites, or of Cephalopoda; but it is quite as necessary to the student of Lamellibranchiata, Gasteropoda, etc., because the same principles of development hold good.

One little matter we feel bound to mention. We dislike to see well-known species like *Am. planorbis*, Sowerby, written as "*Psiloceras planorbe*, Hyatt." This method was condemned by a committee of celebrated naturalists in 1842,[1] and the practice of European authors who write "*Psiloceras planorbe* (Sowerby)," or "Sowerby sp." sufficiently supports their decision. S. S. B.

[1] On Zoological Nomenclature, Report British Assoc. vol. xi. See also Rapport du Commission du Congrès international, Paris, 1881, p. 4.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 21, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.—The following communications were read:—

1. "On some Devonian and Silurian Ostracoda from North America, France, and the Bosphorus. By Prof. T. Rupert Jones, F.R.S., F.G.S.

Of the Devonian species herein figured and described, six species and one variety (four being new) from the decomposed Chert of the Corniferous Limestone of Ontario County, in the State of New York, and new species from the Hamilton Group of Clarke Co., Indiana, have been sent by Mr. J. M. Clarke, of Albany, N.Y., as mentioned in the February number of the Quart. Journ. Geol. Soc. p. 14. From Eighteen-mile Creek, Lake Erie, N.Y., there are two new Devonian species among specimens supplied by Dr. Hinde (*op. cit.* p. 28), and two new *Primitiæ* from Thedford. Altogether five genera (*Bollia*, J. & H., *Moorea*, J. & K., *Octonaria*, J., *Eurychilina*, Ulrich, and *Ulrichia*, gen. nov.) are hereby added to the list of "Hamilton" fossils.

The Devonian *Beyrichia* collected some years ago by M. Dumont at the Bosphorus, and noticed by Dr. Ferd. Römer in the 'Neues Jahrbuch' for 1863, having been kindly lent by M. Dewalque for examination, is figured and described in detail. It appears to be the same as *B. devonica*, Jones, lately described from Devonshire.

Nine new species from Anticosti, in Dr. Hinde's collection, alluded to above, are here figured and described. They are from Mr. Billings's "Anticosti Group" (Divisions 3, 2, 1, and the lowest). The lowest and Div. 1 are both now regarded as of Lower Silurian age, and Divs. 2 and 3 are either Middle or Upper Silurian. A series of Silurian Ostracoda from Canada, submitted by Mr. Whiteaves, F.G.S., and Mr. Ami, F.G.S., have been examined, and critical notes on them are here given.

The Lower-Silurian *Beyrichia Guilleri*, named and compared with other species by M. G. de Tromelin at Nantes in 1875, who found it at Domfront and elsewhere in Brittany, is also figured and described in detail.

2. "On the Age, Composition, and Structure of the Plateau-gravels of East Berkshire and West Surrey." By the Rev. A. Irving, B.A., D.Sc., F.G.S.

The author refers to the view propounded by him somewhat tentatively seven years ago, and since confirmed by the researches of Prof. Prestwich, as to the Preglacial age (probably Pliocene) of these deposits, pointing out the inconclusive nature of the evidence of Glacial age furnished by the presence in them of angular "sarsens." He regards the absence of Miocene marine deposits in this part of North-western Europe as supporting the published view of Zittel and other continental writers that the Miocene period was, in South-eastern England, one of elevation and subaerial waste and degradation of the Weald to the south, and of East-Mercian England to the north-west, this period of waste of the Cretaceous rocks having furnished much of the materials which, in Pliocene times, were carried across a sloping plateau by fluviatile agencies.

The composition and structure of the plateau-gravels are next described, reference being made to previous writings of Prof. Rupert Jones and to the recent papers of Prof. Prestwich. Reference is also made to the explanation suggested by the author seven years ago of the anomalous contrast presented by the lithological conditions of the flint-pebbles and the subangular flint-fragments which are intermingled in these gravels. The great masses of unstratified and unrolled flint débris on the Aldershot Hills are compared with the Preglacial "Schotter" of the lower Alpine valleys. The plateau-gravels are described as occupying altitudes ranging from nearly 600′ (O.D.) at Aldershot and on the north side of Netley Heath, down to 280′ (O.D.) at Bearwood and Farley Hill. A list of 22 localities (with altitudes) is given where actual sections of the plateau-gravels can be studied.

Evidence of glacial action at lower levels (210′ to 240′ O.D.) is then given, sections being described at Nine-mile Ride (Old Windsor Forest), Wokingham, and Sunninghill, and apparent evidence of glaciation at Bracknell, Warfield, and Finchampstead. Photographs of some of these sections are given, and the levels of the plateau-gravels and the glaciated sections correlated by a sectional diagram.

The author concludes, from the evidence given in the paper, that:

1. The Plateau-gravels are of fluviatile origin, their materials having been transported from the Weald-region to the south.

2. They mark roughly the ancient lines of Pliocene drainage of an old elevated Tertiary region, the present valley-system having been mainly determined by their absence.

3. That the modern Lower Thames Valley was initiated in Pliocene times, the main line of drainage having been somewhat further north than at present.

4. That attention to altitudes reveals the fact that the present valley-system was outlined and the major part of it actually excavated in an interval that intervened between the age of the Plateau-gravels and the Glacial Epoch.

5. That the deposition of the Plateau-gravels probably covers most of the geologic time represented by the Pliocene.

A note is added on the probable progressive elevation of the Weald from west to east.

3. "Further Note on the Existence of Triassic Rocks in the English Channel off the Coast of Cornwall." By R. N. Worth, Esq., F.G.S.

A specimen of Triassic conglomerate trawled seven miles south of the Deadman headland, and several miles east of the previously recorded Lizard outlier, is described, and reasons given for its occurrence *in situ*. It contains pebbles of slate, grits, vein-quartz, quartz-felsite, and andesitic rock.

4. "On a New Species of *Coccodus* (*C. Lindströmi*, Davis)." By J. W. Davis, Esq., F.G.S.

A description is given of a small fossil fish from the hard chalk of Hakel in Mount Lebanon; it is nearly related to *Coccodus armatus*, Pictet, but is smaller than that species, does not show an equivalent of the pectoral spine (unless the posterior extension of the scapular arch should be so considered), and the posterior basal extension of the dorsal spine is very different in the two forms. Further, the dorsal spine is nearer to the occipital region in the new form than in *C. armatus*, and is, compared with the size of the fish, a larger fin.

The arrangement of the fins shown in the specimen now described is quite different to that of the Siluroids (*Synodontis* and *Pimelodus*), and the great resemblance of the teeth of *Coccodus* to those of the Pycnodonts, and the cartilaginous character of the vertebræ, indicate a relationship with the Ganoids; but its exact relationship in that group must remain still problematical.

The author proposes to name the new form *Coccodus Lindströmi.*

II.—June 4, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair.

The President referred to the sad loss which the Society had sustained through the death of Mr. Dallas, and read the following resolution, which had been passed by the Council and ordered to be entered upon its Minutes:—

> "The Council desires to record on its Minutes an expression of its deep regret at the death of the Assistant-Secretary, Mr. Dallas, which took place on the 29th ultimo, and of its sense of the loss inflicted on the Council and Society by the removal of one who, for the long period of twenty-two years, had done them invaluable service, and who, by his courtesy, kindliness, and helpfulness had endeared himself as a personal friend to the Fellows."

It was moved by Dr. Evans, seconded by Dr. Hinde, and carried unanimously, that the resolution passed by the Council be communicated to Mrs. Dallas on behalf of the Society also. (See Obituary, p. 333.)

The following communications were read:—

1. "As to certain 'Changes of Level' along the Shores on the Western Side of Italy." By R. Mackley Browne, Esq., F.G.S.

After noticing the prevailing opinion that such changes as he treats of were caused by earth-movements of elevation and depression, the author suggests that the altered levels were due to altered conditions of the Mediterranean. He brings forward objections to the prevailing theory, and remarks on the possibility of periodical oscillating alterations in the tidal depth of the ocean.

After noticing the special characteristics of the Mediterranean, he infers that submergence and emergence on the Bay of Baiae would follow equivalent alteration in the level of the Atlantic waters, such as would be probably developed by changed conditions of astronomical forces; and after discussing the possible dates and periods of the changes at Pozzuoli, makes the suggestion that within a period of two thousand years alterations may have taken place in the astronomical combinations, out of which a change in the surface-level of the oceans generally may have become developed, and wherefrom consequently a synchronous change in the Mediterranean would also occur, and observes that the amount of actual tidal effects has never been ascertained.

2. "North-Italian Bryozoa." By A. W. Waters, Esq., F.G.S.

The Chilostomatous Bryozoa dealt with in the paper are, for the most part, from known Vicentine localities, together with some from two new localities,—Monte Baldo in the Veronese and Ronzo in the Tyrol. Reuss described a number from the Vicentine, but at a time when the chief attention was given to the shape of the zoarium, and the oral aperture, avicularia, and ovicells did not receive the attention now given to them. The attempt is therefore made to bring our knowledge of these beds, which are the richest and most important known in the Lower Tertiaries, more nearly up to present ideas, so that more exact comparisons may be made between Tertiary and living forms.

Several cases are mentioned in which there is great difference of zoarial shape, and also some in which there is great range in the zoœcial characters.

The discovery of *Catenicella* in these beds is of considerable importance, which is enhanced by one of the species having both short beads and longer internodes.

Porina coronata and *Lepralia syringopora* both have a closure, formed by a plate with a tubule in the centre, a structure supposed to be exclusively characteristic of the Cyclostomata.

The position of the beds has been established by Suess, Bayan, Hébert, and Munier-Chalmas, of Bartonian age, and may therefore be called Upper Eocene.

3. "Notes on the Discovery, Mode of Occurrence, and Distribution of the Nickel-Iron Alloy 'Awaruite' and the Rocks of the District on the West Coast of the South Island of New Zealand in which it is found." By Professor G. H. F. Ulrich, F.G.S.

In an introduction the author describes the original discovery, determination, and naming of the mineral in 1885 by Mr. W. Skey, and clears up a misunderstanding by which he himself had been credited with the discovery; he furthermore gives a historical sketch of the further investigations and publications referring to the mineral.

The geology of the Awaruite-bearing district is described. The rocks consist of peridotites and serpentines, breaking through metamorphic schists with occasional massive intrusions of acid rock. The petrographical characters of the peridotites of the hill-complex, including the Olivine and Red-Hill ranges, and serpentines, are considered in detail, and the mode of occurrence of the Awaruite in them and in the sands derived from their denudation is discussed. The author submits a sketch-map of the localities where the mineral has been discovered in sand, including not only George River, but also Silver Creek, Red Hill, and other localities, and quotes Mr. Paulin's belief that it occurs diffused through the whole extent of peridotite and serpentine rocks, and inferentially in the drifts derived therefrom.

OBITUARY.

JOHN GUNN, M.A., F.G.S.,

Formerly Rector of Irstead and Barton Turf, in Norfolk.

Born October 9th, 1801; Died May 28th, 1890.

By the death of Mr. John Gunn. geological science has lost one of her most devoted and enthusiastic disciples. Born October 9th, 1801, he lived to the advanced age of 88, and was thus one of the last links between the geologists of the present day and those who laid the foundations of the science.

His father, the Rev. William Gunn, Rector of Irstead and Barton Turf, in Norfolk, was a man of considerable literary attainments, and more especially devoted to History and Archæology, but taking very little interest in the pursuit of Natural Science.

In an address delivered to the Norwich Geological Society in 1869, John Gunn thus speaks of his early years:—"When at school he was more interested in Natural History than in the Latin Grammar, and his father put the books he was most anxious to study at the top of the library, so that they might be out of his reach. He, however, took every convenient opportunity to get at a volume of Buffon, and thus he gathered some knowledge respecting the habits and the habitat of animals. He could never forget, and he could not describe the electric effect produced upon him by the discovery of the fossil remains of the Elephant, Rhinoceros, and Hippopotamus in the Forest Bed at Happisburgh, etc. He then asked his father how these creatures, now living in tropical countries, could have existed in this? And he received an answer which was still fresh in his memory, and which constantly recurred to him. 'There is much to be done before that can be made out.'"[1] This question probably was put about the year 1822, when R. C. Taylor published his account of Fossil Bones on the Coast of East Norfolk. It must have been soon after this date that John Gunn made the acquaintance of Samuel Woodward, from whom he derived his earliest lessons in geology; moreover his local researches were no doubt stimulated by intercourse with his neighbours, the Rev. James Layton, of Catfield, and Miss Anna Gurney, of North Repps, both of whom became ardent collectors of the fossil mammalia from the Forest Bed.

On the death of his father in 1841, John Gunn, who had been

[1] "Norwich Mercury," Feb. 10, 1869.

Chaplain to H.R.H. the Duke of Sussex, was appointed to the rectory, and for many years his home was at Irstead.

By his marriage with Harriet, a daughter of Dawson Turner, F.R.S., of Yarmouth, he became brother-in-law of Sir W. J. Hooker, and Sir Francis Palgrave. Mrs. Gunn was a talented artist, and accompanied her husband over many parts of Norfolk, their attention being in early years mainly given to archæological studies; geological subjects, however, in turn, attracted attention, and we find in Lyell's "Elements of Geology" an illustration of the Chalk-pit at Horstead, with its paramoudras, from a drawing made by Mrs. Gunn in 1838.

From about the year 1850 until the close of his life, John Gunn's energies were very largely devoted to geology, and in particular to the vertebrate remains of the Forest Bed. He gathered together a very fine collection of the fossils, which he presented in 1868 to the Norfolk and Norwich Museum.

His observations on the geology of Norfolk were brought together in a Sketch, published in 1864, in White's History and Directory of the County. A fourth edition of this article, which was reprinted for private circulation, was issued in 1883, and it was Mr. Gunn's intention to publish the same in a separate and extended form, a task in which he had been diligently engaged to within a few months of his death.

Mr. Gunn took an active part in the formation of the Norfolk Archæological Society. In April, 1864, the Norwich Geological Society was founded, Mr. Gunn being elected President, and Mr. J. E. Taylor, Secretary. Until 1878, the reports of the meetings were published in the local newspapers, but a summary of these (with references) was printed in the first part of the "Proceedings" of the Society commenced in 1878.[1] During this period Mr. Gunn contributed frequent accounts of recent discoveries, and also remarks on various subjects, more especially dealing with the Mammaliferous Stone-bed at the base of the Norwich Crag, the relations of the Norwich Crag and Forest Bed to the Chillesford Clay, and the prospect of finding productive Coal-measures in Norfolk and Suffolk. Many excursions were made by the Society to different parts of the county, and at the annual meetings an account of what had been done during the year was given by the President.

Mr. Gunn also contributed an occasional paper to the Geological Society of London, and to the Geologists' Association. While, however, he was always ready and rejoiced to take up the hammer and go into the field, and to communicate all his information to others, he manifested no great eagerness to publish. Thus it has been that much of his work is embodied in the writings of others, who have acknowledged their indebtedness to him. The recognition of an Upper and Lower Boulder Clay, separated by a mass of sand, to be seen on the coast near Yarmouth and Lowestoft, was due to Mr. Gunn, but published (with acknowledgment) by Joshua

[1] Only one volume has been published, 1878–84; the Society is now merged with the Norfolk and Norwich Naturalists' Society.

Trimmer.[1] The distinction between the Post-Glacial Mundesley River-bed and the older Forest Bed Series was first perceived by Mr. Gunn.[2] His collection of fossil mammalia, and especially the specimens of Elephant, proved of much service to Falconer and Leith Adams; the former remarks that "The interest and value of his collection are only equalled by the liberality with which he makes it available for the ends of science. I need only say in illustration that he has placed all the specimens in his possession at my disposal for this essay, even to be sawn up for sections, if necessary, or for any other use to which they could be turned." [3]

Mr. Gunn's enthusiasm may be well realized when it is remembered that (in 1888) when 87 years of age, he attended the London meeting of the International Geological Congress, and subsequently paid a visit to St. Erth, in Cornwall, to examine the Pliocene Beds that have been discovered in that neighbourhood.

Notwithstanding his devotion to geology, Mr. Gunn, while rector of Irstead, was very energetic in the pursuit of his clerical duties, and filled the position of Rural Dean.

In 1869, after forty years' service in the Church, he resigned his preferment, and ultimately quitted the ministry. This he did because he became convinced that he could no longer conscientiously preach some of the doctrines of the Church of England. In his published letter to his parishioners, he remarks: "It was a hard wrench for me to part from the place of my birth, the scenes of childhood, and of a mature and happy life; from a charming spot where almost every tree and shrub had been planted by myself; and, above all, from parishioners between whom and myself there ever had subsisted a most cordial feeling of good will."

Mr. Gunn died May 28th, 1890, and was buried at the Rosary, Norwich.

WILLIAM SWEETLAND DALLAS, F.L.S.

BORN 31ST JANUARY, 1824; DIED 29TH MAY, 1890.

It is with deep regret we have to record the death of Mr. W. S. Dallas, the able and accomplished Assistant-Secretary of the Geological Society of London; a man universally esteemed and beloved by all, and one whose loss to science it will be difficult to supply.

William Sweetland Dallas was the youngest son of Mr. William Dallas, belonging to an ancient Scottish family, an East India Merchant and a Member of Lloyds', who died in 1842.

Born in Islington, January 31st, 1824, he early evinced a love of Natural History, and when only a boy made collections of Insects with his elder brother in the fields of Hampstead, Highgate, and Hornsey.

[1] See J. H. Blake, Geol. Yarmouth and Lowestoft (Geol. Surv.), p. 28.
[2] Lyell, Antiq. Man, Fourth Edition, p. 267.
[3] Quart. Journ. Geol. Soc. vol. xxi. p. 299. See also E. T. Newton, Vertebrata of the Forest Bed Series, 1882.

He was educated at University College School, where he attained a thorough grounding in Classics, in which he afterwards displayed so great a proficiency. In later years he devoted himself to the mastering of French, German, and Italian, with marked success; and still later, to the acquisition of a knowledge of Danish, Swedish, and Norwegian.

His father failed when William was only twelve years of age, and his elder brothers, John and James Dallas, had both to abandon their prospect of a profession and enter business houses in the City. William, on his leaving school, was also taken into Mr. Milne's office; but City life was so very distasteful to him, that he relinquished it and commenced to study in the old Reading-Room of the British Museum. Here his strong passion for the pursuit of Entomology was allowed to dominate all else for a time, and so eager was the young naturalist to possess a library of his own, that he not only copied out large parts of various descriptive works on his favourite science, but even went so far as to transcribe in neat handwriting the whole text of J. Chris. Fabricius's "Entomologia Systematica" (Tome I. to IV. 8vo. Hafniæ, 1792)—a work of 2677 pages octavo—to each generic description of which he added a coloured figure of the type-species, copied from a specimen, or from some other work.[1]

His devotion to Natural History, and especially to the collecting and preserving of Insects, attracted young Dallas to the Insect-room at the British Museum, where, in the late Dr. John Edward Gray, F.R.S., he found a warm friend and supporter.

In 1847 he commenced to contribute original papers to the Entomological Society of London, which duly appeared in its Transactions from that year to 1853.

In 1849 Mr. W. S. Dallas was elected a Fellow of the Linnæan Society, and in the year following he married Miss Frances Esther Price, youngest child of Liscombe Price, Esq., of London and Abergavenny (one of the lawyers employed in the trial of Queen Caroline).

From 1850 to 1852 Mr. Dallas was engaged in preparing Lists of the Hemipterous Insects in the British Museum.

Immediately on the erection of the Crystal Palace, Sydenham, Mr. Dallas was engaged by the Committee to arrange the Natural History collections in that building.

From 1854 to the end of 1855 Mr. Dallas contributed 28 chapters on Zoology to Orr's "Circle of the Sciences." These were afterwards reprinted as a separate work, in 1856, entitled "A Natural History of the Animal Kingdom."

In 1857 he completed his "Elements of Entomology; an Outline of the Natural History and Classification of British Insects," 8vo. pp. 424, published by Van Voorst.

In 1858, on the resignation of Mr. Edward Charlesworth, F.G.S.,

[1] Of W. S. Dallas's brothers, only the second, Elmslie W. Dallas, appears to have taken up a scientific career. He settled in Edinburgh, and became an artist of some repute, was author of a work on Mathematics, and was elected a Fellow of the Royal Society of Edinburgh.

Mr. W. S. Dallas was appointed Curator of the Yorkshire Philosophical Society's Museum in York, a post which had been, at an earlier date, filled by the late Professor Phillips, F.R.S. (of Oxford). Here he resided with his family, now numbering four sons and two daughters, until the close of 1868.

His life at York, apart from the Museum, was taken up largely with writing for the "Westminster Review," and the preparation of translations of papers for the "Annals" and the "Philosophical Magazine." Mr. Dallas also served, for some years, as one of the staff engaged in the preparation of the "Zoological Record." He was Hon. Sec. of the Yorkshire Naturalists' Club from 1859 to 1869; and, through his friendship with Mr. George Tate, of Alnwick, he was appointed to give a course of lectures each summer to the school maintained by His Grace the Duke of Northumberland in Alnwick; these lectures were most popular and were always attended by their Graces and the neighbouring families.

On the retirement of Mr. H. M. Jenkins, F.G.S , M. Dallas was elected Assistant-Secretary to the Geological Society of London, an office which he held, greatly to the benefit of the Society, until his death in May last.

Mr. Dallas was Editor of the "Annals and Magazine of Natural History" from 1868 to 1890; he was also Editor of the "Popular Science Review" from 1877 to 1880.

Paralysis, of which he had had premonitory symptoms, terminated his laborious life on the morning of 29th May, in his 67th year.

In taking a retrospect of Mr. W. S. Dallas's useful but arduous career, one is astonished at the vast amount of important work achieved by him and the small share of recognition which it fell to his lot to receive. But a glance at the nature of that work will suffice to show that by far the largest and most laborious part was occupied by him either as a Curator, an Editor, a Journalist, or as a Translator, in all of which capacities—however well the duties may have been performed—the κῦδος is but small.

Mr. Dallas was moreover a man of very retiring habits, yet he enjoyed the warm friendship and regard of John Edward Gray, of Charles Darwin, of Sir Charles Lyell, Prof. Sir Richard Owen, of Geo. R. Waterhouse, of Huxley, S. P. Woodward, Bates and Wallace, T. Rupert Jones, and many other of the older naturalists. He frequently acted as *collaborateur* to Darwin, and indexed his works for him with that loving care which only strong personal attachment could have brought to the task. The writer well remembers the words of Prof. Huxley when commending him to the Council of the Geological Society for the post which he held till his death: "Mr. Dallas is one of the hardest workers that I know." To those who knew him intimately Mr. Dallas will also be remembered for the gentleness and amiability of his disposition, his rare modesty, and for his uniform courtesy to all.

Works, papers, and translations, by William Sweetland Dallas, F.L.S.

A List of the Hemipterous Insects in the Collection of the British Museum. Part i. pp. 368, 11 plates. 1851. Part ii. pp. 369–590, pl. 12–15. 1852.

"A Natural History of the Animal Kingdom, being a Systematic and Popular Description of the Habits, Structure and Classification of Animals from the Lowest to the Highest Forms, arranged according to their Organization." London, 1856. 8vo. pp. 818, and 374 woodcuts (originally issued as a series of articles in Orr's "Circle of the Sciences," where it appeared in 28 parts, from 1854 to 1855).

Elements of Entomology: an Outline of the Natural History and Classification of British Insects. London, 1857. 8vo. pp. 424. (Van Voorst.)

Sketch of the Genus *Pœcilocoris*, belonging to the Hemipterous Family *Scutelleridæ*. Entomological Society's Transactions, v. 1847–9, pp. 100–109.

Notice of some Hemipterous Insects from Boutan (in the Collection of the Hon. East India Company), with Descriptions of the New Species. Entom. Soc. Trans. v. 1847–1849, pp. 186–194.

A new Hemipterous Insect from Boutan (East Indies), forming the Type of a New Genus (1849). Entom. Soc. Trans. i. 1850–51, pp. 1–3.

Notice of some Hemiptera from Boutan (Hon. East India Company) [1849]. Entom. Soc. Trans. i. 1850–51, pp. 4–11.

Note on the British Species belonging to the genus *Acanthosoma*, Curt. Entom. Soc. Trans. i. 1850–51, pp. 109–114.

Description of a new Hemipterous Insect forming the Type of a New Genus (*Atelides centrolineatus*). Annals and Mag. Nat. Hist. x. 1852, pp. 359 and 436.

Descriptions of some New Species of Hemipterous Insects belonging to the Tribe Scutata. Entom. Soc. Trans. ii. 1852–53, pp. 6–17.

Description of a New Species of the Genus *Dinidor*, belonging to the Hemiptera scutata. Entom. Soc. Trans. ii. 1852–53, pp. 18–19.

On the Feathers of *Dinornis robustus*, Owen, Ann. and Mag. Nat. Hist. xvi. 1865, pp. 66–69. Ann. Sci. Nat. iv. 1865 (Zool.), p. 292. Zool. Soc. Proc. 1865, pp. 265–268.

On the Occurrence of *Tinnunculus cenchris* in Britain. Ann. and Mag. Nat. Hist. ii. 1868, pp. 75–76.

Translator of C. T. von Siebold's work on a true Parthenogenesis in Moths and Bees. 8vo. London, 1857.

Translator of Prof. O. Heer's "Primæval World of Switzerland," in two vols. pp. 742; with 500 illustrations. (Longmans & Co., 1876).

Translator of "Facts and Arguments for Darwin," by Fritz Müller. 8vo. pp. 144. London, 1869. (J. Murray.)

Author of the articles Rodentia, Chiroptera, Insectivora, Hymenoptera, Neuroptera, Diptera, Aphaniptera, Rhynchota, Orthoptera, Thysanura, Myriopoda, Arachnida, in Cassell's Natural History. 1882.

Translator of vol. v. of Humboldt's Cosmos, 1858. 8vo. pp. 500. (Bohn's Scientific Series.)

Translated the foreign articles for the "Chemical Gazette" (1852–59), for the "Philosophical Magazine," for the "Reader," and for the "Annals and Magazine of Natural History" (1852–90).

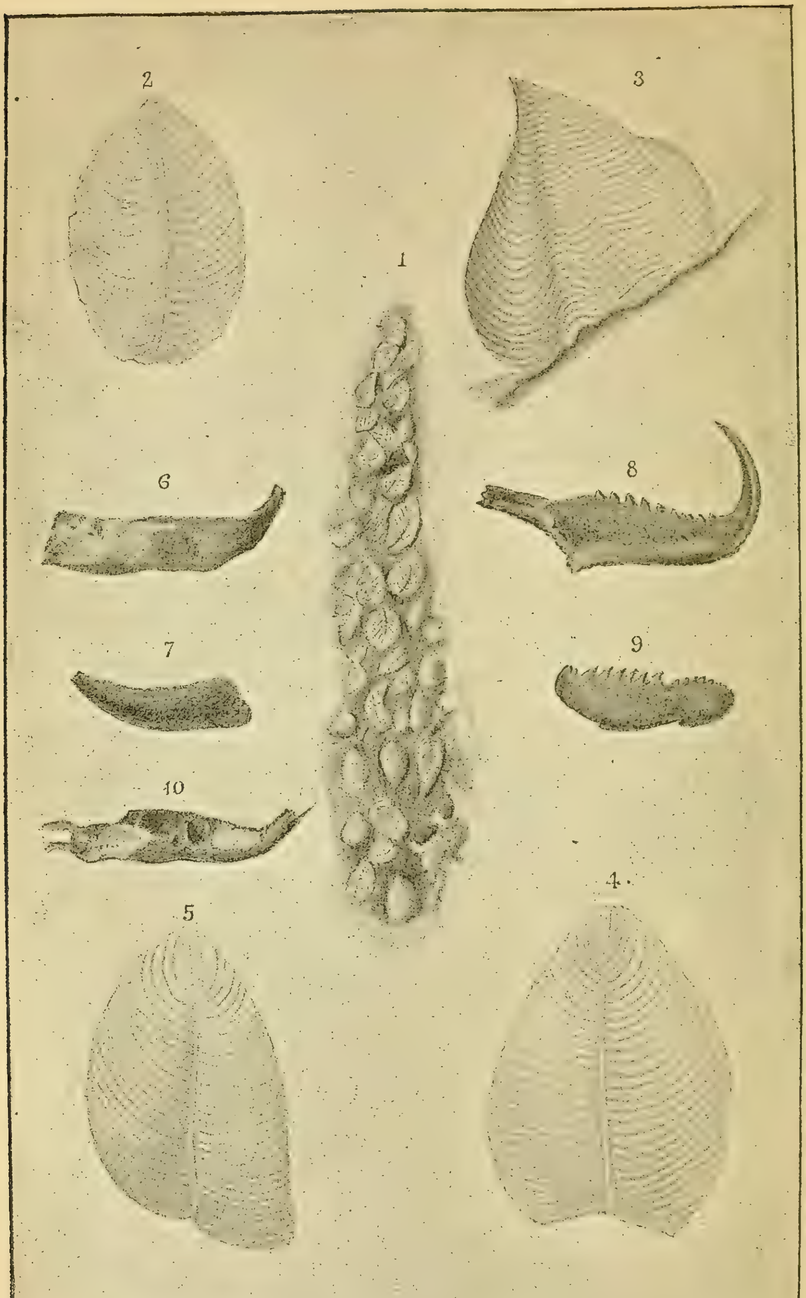
Numerous reviews and articles in the "Westminster Review."

Translator of Buchner's "Man, Past and Present," and Nitzsch's "Pterylography."

H. W.

SIR W. W. SMYTH, M.A., F.R.S.

It is with deep regret we record the death, from heart-disease, of Sir Warington W. Smyth, M.A., F.R.S., Foreign Secretary of the Geological Society of London; which occurred at his residence, 5, Inverness Terrace, on Thursday, the 19th June. An Obituary Notice will be given next month.



Turrilepas and Annelid Jaws: U. Silurian: New South Wales.

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GEOLOGICAL MAGAZINE.
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No. VIII.—AUGUST, 1890.

ORIGINAL ARTICLES.

I.—On the Occurrence of the Genus *Turrilepas*, H. Woodw., and Annelid Jaws in the Upper Silurian (? Wenlock) Rocks of New South Wales.

By R. Etheridge, jun.,
of the Australian Museum, Sydney, N. S. Wales.

(PLATE XI.)

THE correspondence in the life of the Wenlock rocks of Great Britain and those probably occupying a similar horizon in New South Wales is a very marked one. At present, I wish more particularly to draw attention to the occurrence of the genus *Turrilepas* and Annelid jaws in the Bowning Beds of New South Wales. This series of rocks has been enthusiastically investigated by Mr. John Mitchell, who, in his capacity of Teacher of the Public School of that place for some years, had an excellent opportunity of working out the fauna of the series in question. His researches are detailed in two papers, "Notes on the Geology of Bowning,"[1] and "The Geological Sequence of the Bowning Beds."[2] Both the plates of *Turrilepas* and the small Annelid jaws are found in the Lower Trilobite bed[3] of this series, and are chiefly from the typical locality of Bowning Creek.

Plates of Turrilepas. Pl. XI. Figs. 1–5.

At an exhibition of some of the more characteristic of the Bowning fossils at a meeting of the Linnean Society of New South Wales held on June 29th, 1887,[4] Mr. Mitchell showed a few plates of *Turrilepas,* as determined by myself, and this is the first record of its occurrence in Australia, so far as I am aware.

Two or perhaps three forms of plate have been obtained at Bowning, including that termed by the late M. Barrande the 'cancellated plate' (Figs. 4 and 5), and a specimen split in half, and probably representing the entire organism, with the plates displaced generally. The outline (Fig. 1) does, however, so far approximately correspond with that supposed to represent a perfect *Turrilepas,* that I think the plates may be looked upon as more or less *in situ.* In their disunited condition they form a long, slender, sack-like body,

[1] Proc. Linn. Soc. N. S. Wales, 1887, vol. i. (2), p. 1193.
[2] Report, Austr. Assoc. Adv. Science for 1888 [1889], vol. i. p. 291.
[3] *Ibid,* p. 294.
[4] Proc. Linn. Soc. N. S. Wales, 1887, vol. ii. pt. 2, p. 414.

one inch and an eighth in length, by an eighth in width. Only the impressions of two plates are present. If this represents anything approaching the form of the original organism, it certainly differs from any with which the writer is acquainted. There are traces of four rows transversely, and from twelve to fifteen in a row longitudinally, but the entire *Turrilepas* is not preserved.

The proportions of the individual plates are different to those of the English Wenlock species, *T. Wrightii*, de Kon., sp.,[1] being much more elongated and very slender, and the growth imbrications finer and closer. Some of the plates, as in Fig. 1, are not unlike *T. Scotica*, mihi,[2] only wanting the extreme kite-like outline of the latter, and fine drawn-out superior end.

The plates contained in this slender body, Fig. 1, I believe to represent a different species to that represented by Fig. 3. The latter agrees better with *T. Wrightii*,[3] or an undescribed species which occurs in the Wenlock rocks of the Pentland Hills, N.B., than it does with either of the Bohemian species. The subject of Fig. 3 is a short, obliquely deltoid, or triangular, very inequilateral plate, strongly carinate excentrically, and with a short pointed apex, the lower margin being doubly sigmoidal, like the successive surface imbrications, which are much coarser in this form of plate. These transverse lines describe two unequal sigmoidal curves in their course across each plate.

In a third form of plate, not figured here, the carina is central and narrow, the surface on one side plain, the other with very marked imbricating laminar striæ deflected downwards almost at a right angle to the carina, and strongly denticulating the margin of the plate.

Several cancellated plates occur, but there is no resemblance between them and those figured by Barrande from Bohemia,[4] or *T. Scotica*, mihi. The cancellated plates are elongately triangular-oval, the carina simple, and slightly excentric. The imbricating laminæ are distant, except along one margin, where they suddenly become parallel to the latter, and are quite contiguous to one another. Towards the narrower end of these particular plates the laminæ become concentric, thus cutting off the apical portion, which is depressed and round, although not perfectly central, nor truly apical as regards the margin of the plate.

To sum up, there seems to be little doubt that at least two species exist in the Wenlock rocks of N. S. Wales—one represented by Figs. 1, 2, 4, and 5, and a second by Fig. 3. To the former I conceive belong the cancellated plates Figs. 4 and 5, and for these, including the series of plates composing the somewhat disunited sac-like body, is suggested the name of *Turrilepas Mitchelli*, mihi.

The remaining plate, Fig. 3, will for the present remain as *Turrilepas*, sp.

[1] Geol. Mag. 1865.
[2] Mon. Sil. Foss. Girvan, 1880, fasc. 2, p. 214, t. 14. f. 22–24.
[3] Woodward, Q.J.G.S. 1865, vol. xxi. t. 14; Geol. Mag. 1865, p. 470.
[4] Syst. Sil. Bohême, 1872, i. Suppl.

Jaws of Annelids. Pl. XI. Figs. 6–10.

Originally described by Dr. Pander in 1856 in connection with the fish remains of the Russian Baltic Silurian, these bodies have now been satisfactorily shown by Dr. G. J. Hinde to be the horny jaws of Errant Annelids. Their intermediate history has been so fully treated by this author in his papers mentioned below,[1] that it is quite unnecessary to enter into the subject. It is now sufficient to state that these little bodies have been found in strata ranging from the Cambro-Silurian to the Carboniferous, and it is stated by Dr. Hinde that they "occur as small dark shining objects, very varied in form, dispersed through the rock, quite detached from each other, and from the positions they occupied in the head of the animal. . . . . . Except in cases where they have been long exposed to weathering influences, the jaws are of a bright glossy black tint."

Dr. Hinde further adds that the size of the jaws varies between $\frac{1}{12}$ and $\frac{1}{3}$ of an inch in length; that their resemblance to the masticatory organs of recent Annelids is very striking; and that so far as his researches have extended, three families are represented in Palæozoic rocks—the Eunicea, Lycoridea, and Glycerea—the first containing the largest number of forms.

In the case of the Australian jaws precisely the same general description applies. Three forms of jaws have so far been obtained by Mr. Mitchell, with a number of other indeterminable fragments.

Form 1.—A jaw plate (Figs. 6, 7, and 10) composed of a horizontal ramus, terminating anteriorly in a little curved short hook, blunt, and possessing a general average length of two mm. There are no perceptible denticles, so far as observation has gone, whilst the posterior end is excavated into a V-shaped notch. This so manifestly recalls some of the non-dentate species of *Eunicites* figured by Hinde, that I include it in this genus as *E. Mitchelli.* It does not closely approach any of the species given by this author in its more minute detail, nor does it exhibit the same curvature or conical section of the bodies figured as the pincers of *Eunicites* from Gotland,[2] although this may be only the result of pressure perhaps.

Form 2.—The jaw-plate in this variety (Fig. 8) is much elongated, the upper and lower margins sigmoidally curved, terminating forwards in a rather long attenuated hook, which is inclined to the ramus at first nearly at right angles, and almost in the same plane. The superior margin is occupied by a series of small denticles, greatly disproportionate in size to the anterior hook, about eight to ten in number, and apparently placed on a flattened border. Immediately below the denticulate margin is the most prominent and convex portion of the plate, followed below by a concavity, extending along the central part of the plate. This form (Fig. 8) seems

[1] On Annelid Jaws from the Cambro-Silurian, Silurian, and Devonian Formations in Canada, and from the Lower Carboniferous in Scotland, Q.J.G.S. 1879, vol. xxxv. p. 370, t. 18–20.

On Annelid Remains from the Silurian Strata of the Island of Gotland, K. Svenska Vet.-Akad. Handlingar, 1882, vii. No. 5.

[2] K. Svenska Vet.-Akad. Handlingar, 1882, vii. no. 5, t. 1, f. 1–5 (*separate copy*).

to approach nearest to *Arabellites hamatus*, Hinde,[1] or even *A. cornutus*, Hinde,[2] and I propose to call it *Arabellites bowningensis.*

Form 3.—A jaw-plate with numerous teeth along the superior margin, and a simple, short, blunt hook at the anterior end, hardly elevated above, or larger than those which succeed it behind. The denticles are eight to ten decreasing in size backwards, sharp, pointed and rather recurved. The upper and lower margins are sub-parallel, and the plate expanding slightly towards the front, whilst the posterior end is rounded. The lower margin has a small appendage projecting below the anterior part of the basal line.

I take this (Fig. 9) to be a species of *Œnonites*, and to be near *Œ. parvulus*, Hinde.[3] It is proposed to call the species *Œnonites hebes.*

It is hoped that these brief and imperfect notes will be sufficient to call the attention of collectors in New South Wales to these peculiar and interesting little bodies. The Bowning beds are doubtless not the only portion of the Australian Palæozoic series in which they occur, and the writer would suggest rigid search being made for their remains in the Upper Silurian rocks so largely developed around Melbourne, in Victoria, amongst other places.

Localities.—Eunicites Mitchelli, *Arabellites bowningensis* and *Œnonites hebes* are all from the Lower Trilobite bed of Bowning Creek; but the first named has also been found by Mr. Mitchell at Silverdale, near Bowning.

EXPLANATION OF PLATE XI.

Fig. 1. A group of plates of *Turrilepas Mitchelli*, R. Eth., jun. (about twice nat. [size).
Figs. 2, 4, and 5. Three separate plates of same species much enlarged.
Fig. 3. *Turrilepas*, sp., also much enlarged.
All from the Wenlock Limestone, New South Wales.
Figs. 6–10. Jaws of Annelides (much enlarged).
Figs. 6, 7, and 10. *Eunicites Mitchelli*, R. Eth., jun.
Fig. 8. *Arabellites bowningensis*, R. Eth., jun.
Fig. 9. *Œnonites hebes*, R. Eth., jun.
All from the Lower Trilobite bed of Bowning Creek, New South Wales, etc.

II.—Note on the Occurrence of Trigonograptus ensiformis, Hall, sp., and of a Variety of Didymograptus v-fractus, Salter, in the Skiddaw Slates.

By H. Oliphant Nicholson, Esq.

I WISH to take the opportunity of recording the occurrence of the above-named Graptolites in the Skiddaw Slates of the Lake District, as they seem of exceptional interest.

I. Trigonograptus ensiformis, Hall, sp. Figs. 1–2.

The first of these closely resembles, and is probably identical with, the species described and figured by Hall from the Quebec Group under the name of *Retiolites ensiformis*, Hall.[4] Professor Lapworth, however, in 1875, for several reasons, transferred Hall's *Retiolites ensiformis* to the genus *Trigonograptus*,[5] a transference

[1] Q.J.G.S. vol. xxxv. p. 377, pl. xviii. fig. 12, 1879.
[2] *Ibid*, p. 377, pl. xviii. figs. 13, 14, 15.
[3] K. Svenska Vet.-Akad. Handl. 1882, t. 1.
[4] Grapt. Queb. Group, p. 114, pl. xiv. figs. 1–5.
[5] Quart. Journ. Geol. Soc. Nov. 1875, p. 659, pl. xxxiv. figs. 8*a*–8*c*.

which had been previously suggested by my father, so that the species now stands as *Trigonograptus ensiformis*, Hall, sp.

The characters of my specimen of *Trigonograptus ensiformis*, Hall, sp., as far as it is possible to make them out, are as follows. It is the upper half of a sublanceolate diprionidian polypary, about 1½ centimetres in length. There is marked convergence of the margins towards the distal extremity, but the actual tip is not seen. At its widest part it measures about 3 millimetres, and its total length if completed would be about 3 centimetres, if we suppose the margins to converge similarly towards the base, as is shown in the entire specimens figured by Hall. Running up the centre of the polypary is a remarkably well-defined and absolutely straight axial line, and given off from this in alternate fashion are the equally well-defined hydrothecal partitions. Measured vertically there are about ten hydrothecæ to the centimetre. No signs of reticulation are visible.

The specimen which I have thus shortly described was obtained in the Upper Skiddaw Slates (Ellergill Beds), from a small exposure in one of the feeders of Mosedale Beck, near Troutbeck, Cumberland. It is in good preservation, and the characters included in the description are readily determined. From its very peculiar subfusiform shape alone, if for no other character, I think one may safely consider it to be identical with Hall's Quebec form, which Professor Lapworth has now wisely removed from the genus *Retiolites*. The present Graptolite is clearly not referable to that genus, as no trace of punctation or reticulation can be detected, but this is likewise a doubtful feature in Hall's specimens, as he himself hints at the possibility of separating the species as the type of a new genus.

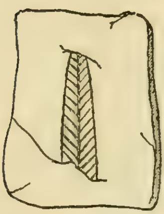


Fig. 1.—The specimen of *T. ensiformis*, Hall, sp., described above, of the natural size. Upper Skiddaw Slates (Ellergill Beds), Mosedale, near Troutbeck.

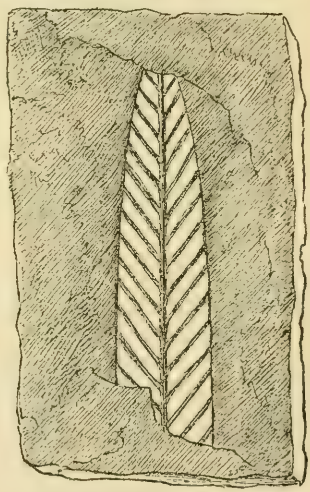


Fig. 2.—The preceding Figure enlarged about four times.

The *Trigonograptus ensiformis*, Hall, sp., described by Professor Lapworth from the Lower Arenig formation, Ramsey Island, resembles my Skiddaw Slate specimen in many respects.[1] If not the same species, it is a very closely allied form, the chief difference being its smaller size. Professor Lapworth also describes another species from the same locality under the name of *Trigonograptus truncatus*,[2] which in many points resembles my specimen, but it cannot be identical with it, as in all the Ramsey Island specimens the polypary is abruptly terminated by a straight line at its distal extremity, while in the present specimen the margins are seen to converge towards the distal end, and clearly meet at a point. Lastly, I cannot identify my specimen with *Trigonograptus lanceolatus*, Nich.[3] The shape of the polypary in that species, owing to the fact that the margins so rapidly diverge distally, is alone sufficient to separate it as a distinct species.

II. Didymograptus v-fractus, Salter, var. volucer. Fig. 3.

The other Graptolite to be described may be provisionally referred to *Didymograptus* v-*fractus*, Salter, of which it appears to be, at least, a well-marked variety. It was obtained from the Skiddaw Slates at Outerside, near Keswick, and is fairly well preserved.

The two branches of the polypary in the specimen in question (Fig. 3) are very distinct. They increase very gradually in width from their point of origin, and attain a maximum breadth of three millimetres.

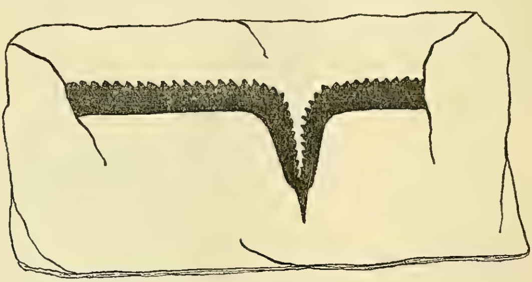


Fig. 3.—*Didymograptus* v-*fractus*, Salter, var. *volucer*, of the natural size. Skiddaw Slates, Outerside, near Keswick.

The sicula in this specimen is not quite complete, but seems to taper gradually to a point. From the summit of the sicula the two branches of the polypary diverge, forming a basal angle of 10°, and at a distance of 9 millimetres from their origin each branch is bent abruptly at right angles to the sicula, so as to form a straight line. The denticles, which at some parts of the polypary are well defined, are slightly mucronate, and there are about 15 to the centimetre.

It will be seen from the above description that the essentially characteristic point in this specimen is the general form of the polypary. The original specimen of *Didymograptus* v-*fractus* was figured by Mr. Salter in a note on the Graptolites of the Skiddaw

[1] *Loc. cit.* supra. [2] *Loc. cit.* p. 660, pl. xxxiv. figs. 9*a*–9*d*.
[3] Ann. and Mag. N. Hist. 1869. ser. 4, vol. iv. p. 232, pl. xi. fig. 6.

Slates,[1] but this figure was not accompanied by any description, and, so far as I am aware, no description has been published by any subsequent writer.

Nevertheless, the form of the polypary in this species is so characteristic, as will be seen from the subjoined figure (Fig. 4), that the species has been accepted as valid by Professor Lapworth in his classical paper on the geological distribution of the Rhabdophora,[2] as also by Herrmann, Tullberg, and others.

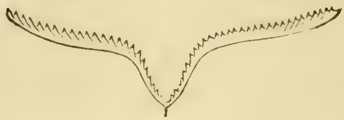


FIG. 4.—*Didymograptus* v-*fractus*, Salter. Natural size. Ordovician (Skiddaw Slates).

In the original *Didymograptus* v-*fractus*, Salter, the basal angle of the two branches of the polypary is considerably more open than in the specimen here under consideration, and the curvature of the branches is effected in a gradual upward sweep. On the other hand, in my specimen, the basal portions of the branches diverge very slightly, and then are reflected abruptly, at right angles to a line traversing the axis of the sicula.

The distinction just pointed out is so marked, that Professor Lapworth, to whom I submitted the specimen, suggested, that though it might be placed under *Didymograptus* v-*fractus*, it would be well to distinguish it by a varietal name; and following his advice I have named the form *Didymograptus* v-*fractus*, Salter, var. *volucer*. It is by no means impossible that future discoveries may serve to raise this to the rank of a distinct species.

With the exception of the doubtful form recorded by Baily from the Lower Bala rocks of Ireland, under the name of *Didymograptus Hisingeri*,[3] all the species of the group *Didymograptus* v-*fractus* are found in the Arenig Beds. Two species belonging to this group have been described by Tullberg,[4] from the Arenig Beds of Sweden, under the names of *Didymograptus balticus*, and *Didymograptus vacillans*, but it is quite unnecessary to discuss the characters of these, as they show no marked resemblance to the specimen now in question. Salter, in the paper above quoted, refers to a Graptolite recorded by McCoy from the Ordovician rocks of Victoria, under the name of *Didymograptus Pantonii*, and states that this shows a considerable similarity to his *Didymograptus* v-*fractus*. McCoy's form, at the time when Salter wrote, had neither been described nor figured, but the resemblance suggested by him was accepted by subsequent writers. Hence Mr. R. Etheridge, jun., in 1874, described and figured a *Didymograptus* from the Ordovician rocks of

[1] Quart. Journ. Geol. Soc. vol. xix. p. 140, fig. 13*e*.
[2] Ann. and Mag. N. Hist. ser. 5, vol. iii.
[3] I regret that I am unable to find a reference for this.
[4] Geol. För. Förh. No. 58, Bd. v. No. 2, p. 39, 1880.

Victoria, under the provisional title of *Didymograptus Pantonii*, McCoy.[1]

McCoy, however, in the same year, but apparently at a later date, described the form in question as a species of *Tetragraptus*, Salter, and as probably identical with *Tetragraptus fruticosus*, Hall.[2] This view of the affinities of *Didymograptus Pantonii*, McCoy, was later accepted by Mr. Etheridge.[3] At the same time it is possible, that *one* of the two forms placed by Mr. Etheridge, in his original paper in the "*Annals*" (*loc. cit.* pl. iii. fig. 21), is really a species of *Didymograptus*, and perhaps may be identical with my *Didymograptus* v-*fractus*, Salter, var. *volucer*. Owing, however, to the fact, that the figure just alluded to only shows a part of the basal portion of the polypary, it is not possible to make this assertion with any confidence.

The only other form which may be alluded to is that named by Baily *Didymograptus Hisingeri*, from the Lower Bala rocks of Ireland, which has been included by Herrmann in the group of *Didymograptus* v-*fractus*, Salter.[4] I am not aware, however, that this form has been either described or figured, and I am therefore unable to offer any opinion as to its real affinity. In conclusion, I wish to express my great indebtedness to Professor Lapworth, F.R.S., for his most friendly assistance and advice in the preparation of this notice.

III.—Secular Straining of the Earth in Relation to the deep Phenomena of Volcanic Action.

By T. Mellard Reade, C.E., F.G.S., etc.

THE application by Dr. Johnston-Lavis of the theory of the secular straining of the Earth, with which my name and Mr. Davison's is connected, to an explanation of the deeper phenomena of volcanic action, is ingenious and suggestive.[5] It will, therefore, I trust, be of some use if I am allowed to discuss and criticize the principles and propositions that appear to me to be necessarily involved in the views put forth by Dr. Johnston-Lavis. Before doing this, I feel it incumbent upon me to point out that Mr. O. Fisher's position with regard to the question seems to have been misunderstood. So far from occupying an antagonistic position, he has done much to mathematically develop the theory; and it is only when we come to its practical application to the explanation of geological phenomena, that he, myself and Mr. Davison differ.

In the "Origin of Mountain Ranges," and elsewhere, I have expressed the opinion that it is "a weak point in most theories of volcanic action that the machinery invoked is insufficient to bring up molten matter from a great depth." I agree with Dr. Johnston-Lavis that the continuous outflow of lava, which has taken place since the dawn of geological history, demands a supply of heat drawn

1 Ann. and Mag. Nat. Hist. 1874, vol. xiv. series iv. p. 7, pl. iii. figs. 21-22.
2 Geol. Survey, Vict. 1874, dec. i. p. 13, pl. i. figs. 9–14.
3 A Catalogue of Australian Fossils, by R. Etheridge, jun., F.G.S., 1878.
4 Die Graptolithenfamilie Dichograptidæ, Otto Herrmann, 1885.
5 Geol. Mag. June, 1890.

from a central source. I have also in the work referred to indicated how this supply of lava may, through local variations of temperature induced by sedimentation, be pumped up to the surface, there to undergo the modifications exhibited in ordinary volcanic phenomena.

The explanations therein attempted of deep volcanic phenomena do not, however, exclude the co-existence of a secular and wider cause, such as that formulated by Dr. Johnston-Lavis.

I have very little faith in the efficacy of tangential compression, induced by secular cooling, as a mountain-building agent, as the shell-of-compression is too thin to produce results of the magnitude we see in nature.

The shell-of-contraction is, as I have shown,[1] vastly greater than the shell-of-compression, and under certain conditions might be a very efficient machine for the forcing up of lava to the surface. It is these necessary conditions that I propose to discuss, and to inquire whether there is a probability of their existence.

Firstly, then, we must ascertain under what conditions the secular contraction takes place. The shell-of-compression is, according to the highest estimate, not more than five miles thick, and according to Mr. Fisher is under two miles.

Below the under-surface of this shell the whole of the crust of the earth, to a depth at which cooling ceases, is in a state of contraction. This shell of contraction, for the proper conception of what takes place, may be divided into an infinite number of shells, each of which contracts at a different rate, the shell of greatest contraction being situated at a maximum depth of 54 miles according to Fisher.[2]

It will thus be seen that it is not a simple case of contraction, like that of the tire of a wheel or the hooping of a gun, but an infinite compound series of tires all contracting at different rates. Assuming that the shells are homogeneous and free from fractures, it would be very difficult to say what the effective contractile force of this compound would amount to, even if we knew the tensile strength of the materials composing it, which we do not.

It could not contract as a whole without internal movements in itself partially destroying its effectiveness for compressing the nucleus. The problem is still further complicated by the compressive-extension produced by the gravitation of the overlying shell of compression as well as of the various shells or matter constituting itself. The idea may be best realized by stretching an elastic band on a plane surface and then weighting it; the weighting will interfere with the contractile force the band would otherwise develop, and if sufficient destroy its movement. I have shown that at the zone of greatest contraction "practically tension could not take place, as the superincumbent strata would by vertical compression elongate the rocks at the zone of greatest contraction to fill the vacuities that otherwise would be created."[3] At what depth compressive-extension would take the place of tensile stress I am not prepared to

[1] Origin of Mountain Ranges, chap. xi.

[2] Physics of the Earth's Crust, second edition, p. 106.

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

say, as the molecular condition of the materials of the earth's crust will be modified by the pressure tending to produce compressive-extension.

In addition to this natural difficulty arising from the conditions being outside any laboratory experiments so far made, is also one arising from our ignorance of the nature and extent of the continuity of strata at great depths. At the surface the rocks are divided by faults and fractures, which must interefere very much with their action as an effective contracting and compressing envelope to the earth's nucleus.

I have now indicated some of the principal dynamical conditions of the problem which it will be necessary to have answered more clearly before we can arrive at anything more than uncertain conclusions as to the effect of the contracting shell on the earth's nucleus, and I have avoided any appeal to geological phenomena either for or against what may be provisionally designated "the contracting shell theory" of deep volcanic action. It would seem that *some* compression must be set up in the nucleus by secular contraction, which if not an effective cause in itself of the expulsion of lava, it may be in conjunction with local thermal effects such as I have indicated in chap. xxi. of the "Origin of Mountain Ranges." I do not think it theoretically necessary that there should be actual rifts in the shells at the depths at which release of pressure will allow the earth's magma to change from the solid to the fluid state. Lava if under constant pressure would force or bore its way through any strata exhibiting local weakness without a rift occurring. Indeed, as I have already explained, no rift could occur at great depths, because of the compression produced by gravitation or otherwise compressive-extension. As I have elsewhere attempted to show, the rifts connected with volcanoes must be comparatively speaking surface phenomena, and the "feeders" or communications of the volcanoes with the central reservoir must be necks or pipes, not fractures.

So much for the earth. If we on the other hand turn to the moon, we find the ring-mountains and other volcanic phenomena studding its surface more readily explicable by the contracting shell theory. As gravity on the moon's surface is only about one-sixth that on the earth's, it is quite likely, as I have already suggested, that the pressure was insufficient to produce solidification of the moon's nucleus, which would therefore be a fluid mass inclosed in a gradually thickening solid shell.[1] If so, we have all the conditions present for effective contraction and expulsion of the fluid magma at the surface, for the shell would probably have a greater coefficient of tensile strength than that of the earth, and its greater thickness proportionally to the moon's diameter would make it a stronger compressing vessel, while the work it had to do, from the smaller size of the nucleus, its fluid condition and low specific gravity, would be much less than in the case of a planet of the magnitude and

[1] See note by me appended to the paper by the Rev. F. Grensted entitled "Theory of the Airless and Waterless Condition of the Moon," Proceedings of the Liverpool Geol. Soc. Session 1887-8.

solidity of our earth. Hence, it is not surprising that there should be signs of that vast welling out of lava we see so plainly on the surface of the moon in the form of rings 50 miles in diameter and 10,000 feet high. The moon therefore seems to afford an example of volcanic action minus water—a phenomenon it was at one time supposed could not exist.

IV.—Vulcano and Stromboli.[1]

By L. W. Fulcher, B.Sc.,
of the South Kensington Museum (Science Branch).

SINCE the excellent and interesting series of papers on the history and description of these celebrated volcanoes by Professor Judd, which appeared in the Geological Magazine for 1875, there is, as far as I know, no connected record of their condition. The islands, though affording such excellent opportunities for the study of volcanic action, are but rarely visited by geologists; but having had the opportunity of examining them myself in the autumn of last year as a member of the party arranged by Dr. Johnston-Lavis under the auspices of the Geologists' Association, I thought it would be well, whilst recording my own observations, to prefix a brief account of the volcanoes since the above-mentioned date. The information, on which the following brief sketch is based, has been derived partly from a series of papers by Prof. Mercalli,[1] on notes derived by correspondence with Sig. Pincone, the former manager of the lately existing Chemical Works at Vulcano, who now resides at Lipari, and partly from papers in various periodicals to which I will refer as occasion requires.

I.—Vulcano.

After having been in almost complete repose for nearly a century, Vulcano resumed its activity in September, 1873, and has not since returned to its former tranquillity. When Prof. Judd visited it in April, 1874, the crater was over 400 feet deep, with a floor whose diameter was about 200 yards. The crater walls rose vertically at the bottom, but afterwards sloped outwards at an angle of about 45°, so that the diameter of the crater rim was about 600 yards. The crater floor was much encroached upon by a talus of materials shaken down from the adjoining crater wall, and especially by a series of irregular cones of fragmentary materials around the orifices of ejection on the northern side. There were four mouths still open, from which considerable quantities of vapour escaped. All over the sides and bottom of the crater fumaroles, some of very large proportions, were discharging acid vapours and gases. Around their orifices were deposits of white, yellow and red incrustations. Halfway down, on the slope of the cone, was a little crater—the Fossa Anticcha—whose floor was about 60 yards in diameter. To the west of this crater, on the north-west side of the cone, was an obsidian lava flow.

In 1873 the crater had been purchased by an English company

[1] Atti Soc. Ital. Sci. Nat. Milan. vols. 22, 24, 27, 29 and 31.

for the purpose of collecting the chemical products, boracic acid, sal-ammoniac, sulphur and alum, which the volcano affords in large quantities and at the time of Prof. Judd's visit there was a well-made road proceeding by zig-zags up the side of the cone, and descending into the crater by means of a viaduct, to facilitate the conveyance of the products of the "fabbrica" near Faraglione. Here the products were roughly separated and forwarded to England for purification.

The cone presented a similar appearance to Prof. Mercalli, who visited it four years later, in 1878, except that another orifice about 12 feet in diameter existed in the east side of the crater floor. It did not then exhale any vapour. It was produced by a slight eruption in 1875. Prof. Mercalli also noticed subterranean rumblings, which were especially audible on the north side. From 1873 to 1879 Vulcano continued in activity, at least one eruption occurring in each year. The ejected material were ashes and lapilli, which in the eruption of July, 1876, were carried by the wind as far as Lipari and Salina. No lava has been emitted in any of the eruptions from 1873 up to the present time. Indeed, the last lava flow was that obsidian stream mentioned above as existing on the north-west of the crater, which is usually assigned, on the testimony of Dolomieu, to the year 1775, but on the authority of Trovatini, a Liparote monk, who in the early part of the present century (1810) described a violent eruption of this crater as having taken place in February, 1771, inclines Prof. Mercalli to this latter year as more probable.

The gases evolved by the fumaroles were often ignited, the flames being tinged with various colours, according to the nature of the minerals (arsenic, sulphur, or boracic acid) which were predominant in their exhalations. In one case, the eruption of 1873, one of the fumaroles burnt with a pale flame which has been attributed to pure hydrogen, but although hydrogen has been detected among the gaseous emanations of this volcano, one cannot help thinking that it was more probably due to sulphuretted hydrogen.

In January, 1880, Mr. Rodwell ascended the cone. Steam was issuing at high pressure from various orifices. On the south-west side of the crater floor was a large opening, from which exceedingly hot air arose. Hot sand and green and blue flames were occasionally emitted, while loud rumblings proceeded from it as if much agitated lava existed below, but no lava could be seen. For the five years 1880–1885 Vulcano seems to have been comparatively tranquil, only emitting dense volumes of "smoke" at times. But in January, 1886, it broke out again with great violence. On the 10th January it ejected scoriæ and ashes, and the eruptions continued with moderate energy till they culminated in a tremendous explosion on the 26th.[1] Incandescent material, scoriæ and ashes, some of the ejectamenta being of very large size, were shot out in abundance with a terrific uproar. The chemical works were destroyed, and many of the workmen in fear abandoned the island and took refuge at Lipari. A small internal cone was in the crater, but after a while disappeared.

[1] Nature, vol. xxi. p. 400.

In May, 1887, Dr. Johnston-Lavis visited Vulcano, accompanied by Sig. Platania.[1] They found that the eruption of 1886 had drilled out the crater so that they were unable to descend into it. The floor of the crater was covered by a layer of purplish-grey ash washed down from the sloping sides, and the fissures in it were blowing off steam in great quantity. The edges of the fissures on the bottom and lower part of the sides were covered by a yellow crust of sulphur, boracic acid, etc.

It presented the same appearance to Prof. Blake, who, however, about the time was enabled to enter the crater by a well-made path.[2]

A very violent eruption occurred in August, 1888. Mr. Narlian wrote an exceedingly graphic description of the phenomena in a letter to Dr. Johnston-Lavis,[3] which has been considered worthy to stand side by side with Pliny the Younger's description of the Vesuvian eruption of A.D. 79. An outburst occurred from the crater on the 3rd of August, and after lasting about a quarter of an hour, ended. This was followed by rushes of thick black smoke at intervals of 20 to 30 minutes, but towards the evening these also ceased. As night approached, the fumaroles on the side of the cone were very active, and began to show flames. Towards morning a tremendous explosion took place, and large incandescent boulders were shot out to a considerable distance, while a burning rain of ashes, lapilli, and stones set light to the trees and vineyards situated around the base of the cone. Mr. Narlian's house was laid in ruins: a huge boulder falling on the roof crashed its way right through the house. A boulder, not less than ten yards in diameter, was ejected nearly three-quarters of a mile from the crater, and buried itself some 10 or 11 feet in the ground. The volcano became quiet on the 6th of August, and remained so for 13 days; but on the 18th the eruptions recommenced with loud detonations.

In a later letter of Mr. Narlian's to Dr. Johnston-Lavis,[4] it is stated that the eruptions were still going on in November, and a change in the character of the ejectamenta was noted. At first, stones were being ejected, but afterwards pumice of a dark rough kind. It is worthy of notice that during this eruption Stromboli did not exhibit the slightest increased activity.

Shortly afterwards the volcano was visited by Signor Giovanni Platania, together with Prof. Silvestri and other gentlemen.[5] The crater did not occupy the central part of the cone, but opened more to the west, and its internal walls showed several beds of altered materials of old eruptions. It was deeper than in 1887. The bottom was formed of enormous blocks of old altered lavas and furrowed by large fissures which were blowing off steam very actively. The coloured sublimations which covered the bottom and walls of the crater in 1887 had disappeared. Eruptions occurred with a loud noise at intervals of a few seconds. A grey "smoke" arose from the bottom of the crater, consisting of ashes accompanied

[1] Nature, vol. xxxviii. pp. 13, 14.
[2] Proc. Geol. Assoc. vol. xi p. 176.
[3] Brit. Assoc. Report, 1888, pp. 665–6.
[4] Nature, vol. xxxix. p. 111.
[5] La Nature, 1888, 2e sem. pp. 198 and 359.

by large blocks which fell back into the crater. Sig. Platania also thought he could detect a certain correspondence of the stronger eruptions with barometric minima.

Prof. Silvestri considers that the phenomena of the eruption described above characterize a special phase of activity which he has also observed at Etna, and to which he proposes to apply the title of *Vulcanian phase*,[1] corresponding to the terms already in use, viz. *Plinian* phase for that of greatest activity accompanied by seismic paroxysms, and *Strombolian phase* for that of moderate activity. The Vulcanian phase is then characterized (1) by intermittent eruptions of enormous masses of vapour, carrying up with it ashes and lapilli and the ejection of fragments of ancient lavas, as well as bombs of fresh lava; (2) by the tranquillity of the ground—only one very slight tremor having been felt before the eruption just described; (3) by the want of lava streams, although the presence of fused material at great depth is attested by the production of bombs.

In September, 1889, I formed one of the party conducted by Dr. Johnston-Lavis to the Lipari Islands. We visited Vulcano on the 21st September, and again on the 23rd. After inspecting the ruins of Mr. Narlian's house and the Chemical Works, we ascended the cone. The crater presented a very different appearance to that which it did before the last eruption. It was almost completely filled up with fragmentary material, being not much more than 50 feet deep below its lowest edge, as judged by the eye. Its diameter was about 600 feet. The surface was covered with brown ash, and strewn with small blocks of ejected bombs. At varying intervals of 20 minutes or so, without any warning and with a rushing sound, inaudible at any distance away, an immense column of fine dust and small pieces of scoriæ rose in the air to a vast height. The scoriæ quickly fell back on the crater rim with a noise like hail, while the dust rose, carried up by the immense quantities of vapour, to several times the height of the cone. Since the cone is about 1000 feet above sea-level, the dust column must have been some thousands of feet in height. Standing on the windward side of the crater, we were able to watch many of these eruptions, but they all presented the same phenomena. One eruption, however, that we witnessed after nightfall on the first day (September 18) of our arrival at Lipari, was of a more violent character. The dust column broke out with a ruddy glow at the base, and some large blocks were shot out on to the sides of the cone, while a bright flash of lightning lit up the scene.

The Fossa Anticcha has now disappeared, being filled up with the fragmentary material which covers the sides and district around the cone to some depth. About the spot where it existed are several fumaroles, from one of which we secured some of the brilliant red (realgar), yellow (sulphur) and white (alum, etc.) sublimations, with which its orifice was surrounded.

Around the base of the cone, and especially on the level ground by Mr. Narlian's house, were scattered large quantities of volcanic

[1] Comptes Rendus, tom. cix. (1889) p. 241.

bombs, with the "bread crust structure," which have been described by Dr. Johnston-Lavis.[1] Here and there we came across a series of slight depressions in the ground, where a bomb had rebounded, and which the wind had not yet had time to fill up with volcanic dust to the level of the surrounding surface. In other places the bombs had broken into a multitude of fragments, or had partially buried themselves in the dust. Some of the bombs contained in the outer coating of obsidian, which surrounds their pumiceous interior, pieces of lava (augite andesite) which had been caught up in them, and also some remarkable inclusions of a milky white substance, which, when collected, were supposed to be quartz. They possessed somewhat the appearance of a sandstone in which the grains of quartz had fused into one another, but a section cut from a specimen reveals a very different tale. With the exception of various small areas of quartz, with small liquid inclosures, it consists of a vesicular isotropic glass, which contains here and there fragments of a felspar much kaolinized, the edges of which fade gradually into the surrounding glass. Mr. G. A. J. Cole, who has very kindly examined the section which I had prepared for me, is inclined to the opinion that it is the result of the fusion of some kind of granitoid rock.

The obsidian, in which it is inclosed, contains in its glassy basis crystals of sanidine and augite, which is very strongly pleochroic, the colour changing from yellow-brown to green. Hence the augite probably contains a large per-centage of soda. There are also numerous small round crystals too small for determination under the microscope only. I understand, however, that Dr. Johnston-Lavis is engaged in an examination of the ejectamenta.

In a short sketch, published in the Scottish Geographical Magazine for March, 1890 (of the visit of our party to the Italian volcanoes), Dr. Johnston-Lavis adduces some interesting evidence from the rupture of the telegraphic cable between Lipari and Sicily of a probable submarine eruption near the island of Vulcano.

Again, a letter from Dr. Johnston-Lavis in "Nature," for May 22, 1890, announces a new eruption of Vulcano on March 15, when a loud explosion occurred. Some windows were broken at Lipari (six miles distant) and a rain of lapilli and condensed vapour fell upon the town. The eruptions lasted with diminishing activity till the 17th, when they ceased. The crater is somewhat deeper than in September, 1889, and some new fumaroles have appeared inside its walls.

II.—Stromboli.

This volcano, on account of its greater inaccessibility, is much less visited than Vulcano, and the records of its condition from time to time are very scanty. Starting from the same point as in the case of Vulcano, namely, Prof. Judd's visit in April, 1874, we find that the thick clouds of vapour prevented an observation of what was taking place at the bottom of the crater. The eruptions succeeded one another at intervals of from two to ten minutes, and consisted of

[1] Nature, vol. xxxix. p. 109.

violent outbursts of steam, carrying aloft fragments of lava, scoriæ and ashes. Prof. Judd thought that there were at least two orifices in the crater discharging independently. On the north side of the crater he observed a fissure encrusted with yellow salts.

Two months later, in June, there appears to have been somewhat greater activity, the volcano ejecting blocks into the inhabited district of the island, which is situated at a distance of about two miles from the crater. I cannot find any records of the state of the volcano for the next four years; but on 4th Feb. 1879, an eruption occurred with a loud detonation which was heard to the south of Vulcano, a distance of 45 kilometres (28 miles). Volumes of "smoke" arose from the crater, while the surface of the sea was covered for some distance with floating pumice. In June of the same year there was also a slight outburst. Mr. Rodwell visited Stromboli in 1880, and states that it was giving off enormous quantities of steam, but the ejection of red-hot scoriæ only occurred at long intervals. The volcano remained in a tranquil state till 1882, when a very important eruption took place.

After several minor outbursts in the months of January, March and April, the activity culminated in November. On the 17th of this month at 10·30 p.m. a loud detonation was heard, and scoriæ and ashes, together with steam, were ejected in great abundance for a few minutes and then ceased. A subsultory earthquake shock was felt, indicating internal disturbances, and some hours later the mountain was lighted up by an immense quantity of incandescent material which was thrown to a considerable height. Simultaneously another earthquake shock was perceived, and a detonation, "as if 1000 cannons had exploded at once," caused great consternation among the inhabitants. No one at Stromboli had ever heard such an explosion. It was caused by the opening of five lateral mouths on the slope of the Sciarra about 100 metres below the ordinary crater. These discharged incandescent material and ashes with greater violence than the central crater had ever shown. The eruptions continued with more or less violence till December, when the lateral mouths closed, and the central crater resumed its ordinary activity. No lava issued during the eruption, and Vulcano remained perfectly tranquil. Prof. Mercalli thinks that this eruption is probably the most violent which has happened during the recorded history of Stromboli, a period of some 2000 years. The inhabitants had never seen their volcano in such activity, and even thought of abandoning the island. Another very remarkable feature of this eruption is that the ejectamenta issued from lateral mouths. Never before has a lateral eruption been recorded at Stromboli.

In February, 1883, we gather from the notes supplied by Signor A. Pincone to Prof. Mercalli that Stromboli again broke out and covered the surface of the sea for more than a mile from the island with a reddish dust. Again, in March, a detonation was heard and the sea covered with pumice. On the 3rd July great quantities of ash were ejected, and the volcano subsided into a more tranquil state than usual, which continued for the next few years.

In June, 1887, Dr. Johnston-Lavis and Signor Platania visited the crater. They state that it was very quiet, only throwing out a very few fragments of pasty lava cake at long intervals. In fact, only four or five explosions were witnessed by them in a four hours' stay at the summit. So slight were the ejections that they were even able to land on the beach at the foot of the Sciarra. Five months later, however, the activity increased, since on November 17th the sea was covered with pumice. It was in a state of repose in August, 1888, according to Signor Giovanni Platania.

The 19th September was set apart for our examination of Stromboli during our stay at Lipari. We ascended the cone from the north side. In the crater, when the wind carried off some of the vapour, we could make out five mouths, from one or other of which an eruption occurred at intervals of a few minutes. The eruption began with a dull report, accompanied by volumes of steam, whilst a multitude of pieces of red-hot lava were shot into the air to a height of two or three hundred feet and fell back partly into the crater and partly around the sides with a sharp rattling sound. The scoria lumps which happened to fall on the slope of the Sciarra rolled in a cascade towards the sea, but few of the pieces reached it. Now and then, between the eruptions, a curious ring of white vapour would arise from one of the mouths, and gradually ascend in the air, revolving and twisting, but preserving the form of a ring for a considerable time. After watching the action going on below from the summit, we descended along the western arm of the ridge and reached a spot where we could watch the eruptions nearly on a level with the erupting vents. Here quantities of light lapilli fell on and around us after every explosion. Continuing our way along the precipice, we were able to obtain a view of the crater from the front, that is, the seaward side, where the same phenomena presented themselves. Just below one of the mouths, and for a short distance down the Sciarra, a piece of lava would now and then break off and roll towards the sea, exposing a red-hot surface beneath. The effect of the eruptions was very fine at night. We did not observe any coloured incrustations in the crater nor were we able to see the lava rising and falling in the tube as described by Spallanzani and others.

Signor Platania, who accompanied our party, has written a description[1] of the state in which we found both this volcano and Vulcano, and compared it with the appearance it presented on his former visit.

Such, then, is a brief description of the phenomena presented by these volcanoes since 1874. The record is indeed very scanty, and there is great need of the systematic observation and examination of the materials ejected. Of late years, however, there seem to be more workers in the field, and I believe an observatory at Lipari is in contemplation, so that greater use will be made of the facilities which these islands afford for the study of volcanic action.

[1] Bol. Osser. Meteor. d. R. Ist. Naut. Riposto, xv. (1889).

V.—On the Base of the Sedimentary Series in England and Wales.

By the Rev. Prof. J. F. Blake, M.A., F.G.S.

(*Concluded from the July Number, p.* 315.)

3. *North-west Carnarvonshire.*—There are here two or three separate areas which, at all events historically, must be considered more or less independently, viz. the district between Bangor and Carnarvon, the Llyn Padarn and Moel Tryfaen range, and the Lleyn Peninsula. Except in reference to the last of these, it is certain that the belief in Precambrian rocks in Carnarvonshire began with Prof. Hughes. This author, indeed. quotes Prof. Sedgwick as recognizing such rocks here, but the passages he quotes have a very different meaning in the original. The slates near Bangor and Carnarvon, which Sedgwick says are amongst the oldest of North Wales, are those which occur "along the shores of the Menai Straits from Bangor to Carnarvon," which he describes as "dark earthy-coloured slates which, were we to judge only by mineral structure, might easily be confounded with Upper Silurian rocks," and these are "cut through by a great intrusive rib of syenitic porphyry of a different epoch, which ranges nearly with the beds." In the section he draws, from the Menai Straits to Glyder Fawr on the Carnarvon Chain, in an E.S.E. direction, which therefore must pass near Carnarvon, he indicates by the same letter *a* the rocks on both sides of the porphyry, and inserts no fault. From all this it is plain that what Sedgwick regarded as the very oldest rocks in North Wales are those which have since been recognized as Carboniferous shales on one side, and Arenig slates on the other! Like Prof. Sedgwick, Prof. Ramsay also taught the intrusive character of the crystalline rock, about which, at Llyn Padarn, he held a very peculiar theory. It was in 1878 that Prof. Hughes for the first time brought forward evidence in favour of the Precambrian age of the "porphyries," and of the rocks near Bangor. The principal point of his paper is that there are always conglomerates on the eastern boundary of this group, which proves that the latter are older than the conglomerates. But what is the age of these conglomerates? On this point he brings forward no evidence whatever, but merely *asserts* that the conglomerates "form everywhere the basement bed of the Cambrian." Now there are three conglomerates in question: (1) that at Twt Hill; (2) that at Llandeiniolen; (3) that on the east of Bryniau Bangor. All these three Prof. Hughes takes to be the same, and Prof. Bonney now identifies Nos. 1 and 3. My own examination of the district, however, yielded satisfactory evidence that they are all of different ages. The Twt Hill conglomerate is quite of a different character to either of the others, being far more quartzose; it is followed rapidly at that spot first by grits and then by slates, which are perfectly continuous with those carrying Arenig fossils, and the same succession may be traced on a curved line as far as Llandeiniolen, and thence along a line which runs east of and is transverse to the Bryniau Bangor conglomerate. This then is an Arenig conglomerate forming

the base of that series, and unconformable on all the beds below. The Llaneiniolen conglomerate contains a different set of pebbles, some of which correspond to the Twt Hill igneous rock, and the neighbouring felsites. It runs obliquely to the Arenig conglomerate in a N.N.W. direction, and is followed on the dip side by other conglomerates and ashy beds, with intervening compact halleflintas or slates, as demonstrated by Prof. Bonney. It is thus entirely distinct from and older than the Twt Hill conglomerate. Further north on the same dip comes the Bryniau Bangor conglomerate in the midst of similar halleflintas, and this therefore is a higher conformable bed of the same series. But though of the same series, it is not identical with the Llandeiniolen conglomerate, as is proved by the careful stratigraphy of Professor Bonney against the statement of Prof. Hughes, who acknowledges not to have examined the critical parts of the area. The Bryniau Bangor conglomerate is not, therefore, in spite of its large pebbles, the base of any series, but is due to the denudation of some new mass of felsite which has previously been covered. The only basal conglomerates as proved by stratigraphy are the Twt Hill one, which is the base of the Arenig, and the Llandeiniolen one, which is the base of some older series. These results are in absolute accordance with the mapping of the Geological Survey. All therefore we know about the group of rocks between Bangor and Carnarvon is that they are Pre-Arenig.

The Pre-Arenig rocks are considered by the Geological Survey to be altered Cambrian intruded upon by felspar porphyry. This last conclusion cannot possibly be correct seeing that the bedded portions contain fragments of the porphyries, etc., which are nowhere else to be matched in the district. The *tout ensemble* of the bedded rocks is exceedingly volcanic, being almost entirely conglomerates, agglomerates, ashes, and halleflintas. We must not assume that the Geological Survey has overlooked this fact, and has imagined that the ordinary slates and grits could change into such as these. We must read the words "altered, Cambrian" with a comma, and as intended to indicate two distinct opinions, that they must be classified with the Cambrian (though they may be lower beds than any elsewhere seen), and that they are altered. Perhaps their only direct connection with ordinary Cambrian rocks is the occurrence amongst them on the west of Bangor and elsewhere of purple slates. They are entirely cut off on the east by the overlap of the Arenig. Under these circumstances all that can be said at present is that as the Cambrians nearest on the east have no base, and these have no summit; it is *highly probable* that the two wants are satisfied together, by these being considered as basal Cambrian.

With regard to the felsites and Twt Hill rock, the fact of the Llandeiniolen conglomerate containing their fragments shows that they were in existence at the time of its formation, and must therefore antedate it, but by how long an interval will depend on their nature. It is well known that attempts have been made to prove that they are bedded; but such attempts, as in the case of St. Davids, have been entirely unsuccessful. It was Prof. Bonney who first made the attempt in the case of Twt Hill. Admitting that he "saw nothing absolutely irreconcileable with an igneous origin," his doubts were set at rest by the observation of a conglomerate—the Arenig conglomerate—which was apparently part of the mass. These doubts should be raised again, now that the error of this observation has been made clear. There is, in fact, no sign of true bedding anywhere in the hill; there are only segregation bands of more felsitic-looking rocks, and a certain amount of brecciation in the neighbourhood of the fault. The impossibility of finding any is shown by the fact, that while Prof. Bonney states that the Twt Hill group is the highest of the metamorphic series, Prof. Hughes places it at the base, with the "Crug beds" above. It can only be theory indeed which prevents any one from recognizing the former as granitic, and the latter as granophyric, and both therefore of igneous origin. The same is the case with the Dinorwic felsites. Though called "beds" by Prof. Hughes, they are as good volcanic rocks (very possibly flows, as there are occasionally ashes with them) as any of more modern date, as has been well shown by Prof. Bonney. This being the case, they need not be separated by any long interval from the detrital rocks which contain their fragments. It may be said, perhaps, that the Twt Hill rock, being granitic, must have been buried deeply when formed, and have required a long time for the denuding forces to reach it. But this would not be a just inference, when we remember that quite as granitic a rock is found in the Ponza Isles in association with surface volcanic materials, which are probably exceptionally bad conductors of heat.

The association of these three types of rock in one small area, granite, quartz felsite, and stratified volcanic materials, calls to mind very forcibly the similar association at St. Davids, and the upper part has by Professors Bonney and Hughes and Dr. Hicks been referred to the Pebidian. The actual similarity of the individual rocks is not very striking, but it is certainly greater than the similarity between the Pebidian and any rocks of volcanic origin in Anglesey. My correlation of the Pebidian with the latter instead of with these depended upon the general stratigraphical evidence that the Pebidians could not be Cambrian, and that these rocks partly are. In this I was probably wrong; but if so, then, as it is impossible to create a separate "system" for these Carnarvonshire rocks, jambed in as they are between higher Cambrian and Monian, both they and the Pebidian will have to be brought into the Cambrian as basal deposits.

The great porphyry rib from Moel Tryfaen to Llyn Padarn must now be considered. Here again it was Prof. Hughes who first suggested in 1877 that the beds passed through in an adit on Moel Tryfaen might be Precambrian, and accordingly the locality was examined in the following year by Dr. Hicks, who adopted the suggestion. It should be noted that there is abundant evidence in the cleavage of the Penrhyn slates, which extends in a remarkable manner into the felsites, that there has been enormous pressure here at work, fit to give a more or less schistose character to the most solid igneous rock. Yet the "evidence" on which Dr. Hicks "feels justified in placing the whole of the so-called altered Cambrian of Moel Tryfaen and the neighbourhood and the whole of the rocks . . . coloured as intrusive felstone and porphyry . . . . with the Precambrian rocks," is the schistosity of certain portions of a mass for which he can still find no other general name than "felstones and quartz felsites," together with "ashy" rocks of the same type, one of which, according to Prof. Bonney, is a Cambrian conglomerate. This evidence is manifestly insufficient. More convincing is Dr. Hicks's explanation of the difficulties which seem to have prevented Prof. Ramsay and even Prof. Sedgwick from perceiving that the conglomerates of Llyn Padarn and elsewhere are derived from the rocks beneath them. That they are so will probably be always henceforth acknowledged in any interpretation of the district. But as to the nature of the porphyry itself, we are left in no doubt by the examination of Prof. Bonney, whose conclusion is irresistible that "they are neither intrusive nor metamorphic in the ordinary sense of the word, but parts of ancient lava-flows which, were they of modern date, we should probably not hesitate to call rhyolites." But when we have learnt this, we have not learnt all. Even a stream of lava must flow upon something. Can we discover what that was? If it were true, according to Dr. Hicks, that the conglomerates flank it *on both sides*, the discovery would probably be hopeless. But Dr. Hicks should really have more consideration for the legs of his brother geologists than to write down such a statement without indicating where it may be verified. It has given me many a mile's weary tramp up and down the hills along their western border to find any such conglomerate, but none have I ever found. From the general slope of the whole series we should on the contrary expect to find the bed of the lava-stream on the western side; and there, as I have shown at Bryn-efail, we do find it, and see the lava tearing up and altering the underlying slate and grit now turned on end. Until this section is otherwise explained, we must admit that there are Cambrian beds below the felsite, and the conglomerate cannot, however attractive the hypothesis, be the base of the series. It is nothing wonderful that there should be a contemporaneous felsite in the Cambrian rocks; indeed the felsite of Moel Gronw is another, and I have even seen one lower in the series in the valley near Glanrafon south of Carnarvon.

The third locality includes the various exposures of igneous rock and the schistose beds on the west of the Lleyn Peninsula. With regard to the latter, there is at all events, and always has been, this common opinion, that whatever the Anglesey rocks are, these are the same. But with regard to the igneous masses, it is Dr. Hicks alone who is responsible for their Precambrian age. I have already given evidence which shows that they cannot possibly be so; to rebut which Dr. Hicks falls back on imaginary "thrusts." I say "imaginary," because no evidence has ever been given of their existence, and in one case at least—that of the Hinvain syenite

—Mr. Harker has shown that on the eastern side it is intrusive in the Ordovician slates!

The net result, therefore, at present, of recent work in N.W. Carnarvonshire, is this, that, with the exception of the western side of the Lleyn Peninsula, there is nothing proved to be Precambrian in age.

4. *Malvern.*—Of this small area I cannot speak with so much confidence, having never examined it with care. There can now be no doubt that below the ordinary Cambrians there are here two distinct groups of rocks; one, presumably the younger, according to the account of Dr. Callaway, is so like the Caradoc and Wrekin masses that, in the lack of any direct evidence, its age and relations must be determined by theirs; and the other, the main mass of schistose crystalline rocks, which, since their description by Dr. Holl, are generally admitted to be of Precambrian age. The absence from among them of any ordinary unaltered sediments, and their intimate connection with igneous masses of a foliated type, renders it probable that they are older than any other rocks in England or Wales, unless it be the equally undetermined Cornish and South Devonshire schists.

As to their origin, there are two very distinct "views" before geologists. On the one hand, Mr. Rutley regards the main mass as ordinary sediments metamorphosed into schists, and intruded upon after their formation by igneous masses. On the other hand, Dr. Callaway affirms that there are here no sediments at all, but that the whole was originally composed of massive igneous rocks of two distinct types, which interpenetrated each other in veins. These veins were then drawn out by shearing, and where this process was carried furthest, the whole rock recrystallized and produced the ordinary schists.

Without a detailed knowledge of the district, which might afford some independent criterion, one can only choose between these two accounts on general principles. It appears we may divide the rocks into three categories; the massive crystalline rocks, schistose rocks in the neighbourhood of these, and schists with no visible connection with igneous rocks. About the first of these there is no question. That shearing and resulting schistosity and mineral change may be demonstrated in some cases belonging to the second category seems proved by Dr. Callaway's observations; but that the schists and gneisses away from all obvious igneous masses are reconstructed out of the disintegrated materials of such masses would seem to require more proof than the *apparent* passage of such schists into those of the second category. Moreover, Mr. Rutley describes part of these schists as quartzites with rounded particles, and others as containing fragments of felspars—phenomena which would be impossible on Dr. Callaway's explanation. It would appear from this, that no single explanation will cover all the foliated rocks of the Malverns—and that the separation of those of one origin from those of another has yet to be worked out.

5. *Shropshire.*—According to the mapping of the Survey, and the

writings of Murchison, there was nothing Precambrian in this county. The whole of the Longmynd rocks from the Slopes of Caradoc to the Stiper stones was one continuous sequence of Cambrian rocks, of which no base was seen, and the volcanic rocks of Caradoc and the Wrekin were intrusive greenstones affecting both Ordovician and Cambrian strata. The first blow to the correctness of this interpretation came from Mr. Allport, who showed that some part of the "greenstones" in the Wrekin district were rhyolitic lava-flows, and another part in the Wrekin range itself consisted of bedded volcanic ashes. This was followed up by Dr. Callaway, who proved that beneath the Tremadoc (Shineton) shales were other Cambrian rocks lying unconformably on and therefore younger than the Wrekin rocks. Thenceforth it was clear that these volcanic rocks are in some sense Precambrian, and the same thing was proved with regard to Caer Caradoc.

This was the starting point for a search after further Precambrian formations in the district, and first it was noted by Dr. Callaway that in the Ercal there is a mass of coarsely crystalline rock of acid type and without foliation, associated with the volcanic rocks of the Wrekin. It seems to have been more or less assumed that this was not an intrusive rock; and under the influence of the theory that ordinary sediments became by metamorphosis massive crystalline rocks, it was considered, from some peculiarities in its structure, to be of such an origin and of earlier date than its surroundings. At the same time, some small patches of foliated rock were found at the south end of the Wrekin, on Primrose Hill, and these were referred to the same period as the Ercal rock, and both were correlated with the rocks of the Malvern. It may here be noted that this interpretation involves the assumption that in the same massif there can be ordinary sediments converted into massive crystalline rocks, and massive crystalline rocks converted into gneisses, at approximately the same epoch. The superior antiquity of these crystalline rocks was thought to be proved, however, by the discovery at Charlton Hill of a conglomerate, apparently forming part of the volcanic series—and in such situations as to be obviously older than the quartzite—which contained pebbles of similar crystalline rocks. A third group of micaceous schists was also indicated near Rushton, whose relation to all other rocks of the neighbourhood was obscure. The Precambrian age of all these was evidenced by their relations to the quartzite, and the Longmynd conglomerates containing their fragments. A little later a series of isolated patches on the western border of the Longmynd, which were for the most part coloured as intrusive greenstone on the Survey map, were examined by Dr. Callaway and considered to be Archæan, partly because some of them were like the old Wrekin rhyolites; partly because traces of bedding were to be found in others; and partly because a conglomerate in the Longmynd series in one place dipped away from the supposed Archæan mass, and contained some rhyolitic pebbles. The same evidence was thought to prove a synclinal in the western part of the Longmynd, by which the lower beds near their junction with the Archæans were brought to-day, though with the aid of a fault.

With regard to the relations of the Longmynd series to the volcanic masses on the eastern side, they were stated to be separated by a fault, so that no conclusion could be drawn from observations here. About three years ago Dr. Callaway began to think that the Longmynd series itself, which had always been assumed to be Cambrian, but which, as a matter of fact, according to his observations, was everywhere separated by faults, might not, perhaps, belong to that system. The relation of the Longmynd rocks on the west of the volcanic group to the quartzite on the east not having been demonstrated, their correlation was always difficult; but even if the Longmynd were Cambrian, it seemed most probable that they represented an earlier part of it than the quartzite. The lower down, therefore, the quartzite is, the less room is there in the same system for the Longmynd rocks. Recently, according to the statements of Prof. Lapworth, the quartzite, or rather its associate, the Comley sandstone, has been shown to contain the oldest known Cambrian fauna, and therefore to be very near, if not at, the base. This would leave no room in the Cambrian for the Longmynd series, and "render their Precambrian age a matter of fair probability."

According, therefore, to these observations and views, there may be three or even four distinct Precambrian formations in Shropshire. The highest would be the "Longmyndian," isolated from all others, but containing pebbles of the next series. Then the volcanic group or "Uriconian," isolated from the Longmyndian, and giving no clear stratigraphical indications of its relations to the next, but containing pebbles of it in its conglomerates; and then the "Malvernian," regarded as the oldest and most metamorphosed of all. In some undefined position with relation to these is a mass of schists (which has not yet been called the "Rushtonian"!)

I have now to state the bearing of my recent researches in the district on these conclusions. From what I had seen previously of the Longmynd and Wrekin, and what I had learned elsewhere, I had accepted the conclusion that the "Uriconian" rocks were older than the "Longmyndian," and having suggested that the latter were Upper Monian, the former became Middle Monian, and, as I then thought, in part equivalent to Pebidian; and I thought to find evidence of the correctness of this view, which differed only, if at all, from that of Dr. Callaway, in assigning a definite age to the Longmynd group. But facts are stronger than views. In studying the Longmynd series I found there was on the whole great regularity, in the lower part; but that, on reaching the conglomerates and grits, great irregularity was displayed. While the eastern members of the series marched straight across hill and dale, scoring the slopes with the edges of vertical beds, the western portion commenced with horizontal boundary-lines, and displays of outliers and inliers; in a word, there was an unconformity between the grits and conglomerates on the west and the underlying slates and greywackés on the east, the latter coming in contact with different subdivisions of the former, even down to the lowest. Now it is only this upper series that has been shown by Dr. Callaway to contain so many rhyolite pebbles. This alone, then, is necessarily younger than the Uriconian. At the same time, the title "Longmyndian" ceases to be applicable to the whole; and if the upper part be Cambrian, there seems no reason to disturb the existing terminology, which makes the "Longmynd group" part of that system. But the Cambrian age of even this upper part requires to be proved, if it be cut off by a fault and bent into a synclinal on the west, as described by Dr. Callaway. This point was, therefore, next examined. I could find no continuous fault, but only a local one near Lyds Hole, in the neighbourhood of which is the only reversed dip in the district; elsewhere it is steadily towards the west, and everywhere the upper grits are succeeded on the dip by pale shales, continuing up to the conformable Stiper stones. Thus the series is conformable and continuous from the Stiper stones downwards to the lowest grits, and hence we are thoroughly justified in calling the latter Cambrian. I had, however, to satisfy myself of the nature of the small exposures of rock which had been referred to the Archæan by Dr. Callaway. They were all examined with care, and evidence obtained, and elsewhere recorded, that they were none of them really Archæan, or had anything to do with Precambrian rocks.

The division of the Longmynd by an unconformity into an upper or "Cambrian" series, and lower, or "Upper Monian" series, has another, and unexpected result: it leaves the relative ages of the Upper Monian and Uriconian undetermined, and this had next to be investigated. If the two were really separated by a fault, it would be hopeless; but I found that though a fault does run in the valley between Caer Caradoc and Church Stretton, it does not affect the relation sought for, and the two groups do actually come side by side, and there is a fourfold evidence that the Uriconian is the younger. 1. They come together along a very curved and crooked line, not to be accounted for by faults. 2. The Monian beds are here very fine slates, and not in any way derived from the underlying beds, as they should be if younger. 3. They are much altered near the line of junction. 4. Portions of them are caught up amongst the volcanic rocks. Although the last two statements are the best interpretations of phenomena rather than indisputable facts, all four reasons together can leave little doubt that the Uriconian are the younger rocks. In saying this I am changing former "views" on account of actual evidence, and the change is far-reaching. The notion that the Uriconian corresponds with any part of the rocks of Anglesey (except the Beaumaris rocks) must be given up, and they must be compared with the rocks of Bangor, as has been done by Prof. Bonney. Lying as they are thus shown to do between Monian and Cambrian, their classification is a matter of "view" only. My own is that they belong to the interval between the two systems, and it is a matter of indifference with which they are bracketed. The evidence from other districts is conflicting, even if we are justified in assuming the correctness of our correlations. The Pebidians at St. Davids, like the Uriconian (their equivalent), are sharply marked off from the overlying Cambrian; the Bangor beds are not marked off by any great interval. But on both these points there are differences of opinion. Pending therefore further evidence, one "view" is as good as another. My own at present tends rather to give more weight to the Bangor succession than to the St. Davids, and to classify the Uriconians, if they *must* be classified, with the overlying though unconformable Cambrians. There remain the gneisses and massive igneous rocks of the Wrekin and the Rushton schists. But here again we have nothing but "view." Both are certainly older than the Cambrian quartzite, but are they older than the Uriconians? As to the Rushton schists, there is no positive evidence whatever. They are most like some rocks in Anglesey of any I know, and I therefore *think* they are older even than the Longmynd, *a fortiori* than the Uriconian. In the Wrekin itself there is too much faulting at the junction of the eurite with the rhyolites for any positive evidence to be produced; but I *think* the former is intrusive in the latter, because of its mode of occurrence, and because other small patches like it are found isolated in the rhyolites like intrusive bosses. At Charlton Hill, Dr. Callaway, as before noted, has found conglomerates which, if they were part of the Uriconian, would prove these to be the younger by containing eurite pebbles; but according to my observations these conglomerates are merely superficial, and probably belong to the lowest Cambrian, so that evidence fails us. As to the gneiss of Primrose Hill, it is such a tiny patch, and is associated with another tiny patch of hornblende schist, that it seems impossible to have been formed on the spot; and my "view" accordingly is that these patches are masses of lower rock brought up in the eruption of the eurite. All I feel sure of, however, is that the contrary supposition is no more than a "view."

6. *Devonshire and Cornwall.*—In this area we have mica and hornblende schists which are considered by Prof. Bonney and Gen. McMahon to be Precambrian stratified rocks. By Mr. Teall and others they are thought to be dynamically metamorphosed igneous rocks. I do not know the district at all, though I hope to study it shortly. If, however, as Prof. Bonney says, some of the rocks bear a striking resemblance to the chloritic schists of Holyhead, this would be a justification of the view that they are really Lower Monian, if it were safe to judge by mineralogical similarity alone.

Such is the present state of the knowledge acquired on Precambrian rocks in England and Wales. Probably few of the conclusions above stated are universally accepted, which is not perhaps to be wondered at, as no conclusions could possibly be stated that are.

What I have here given have been arrived at by making further observations to test the hypotheses which have been suggested to others by a smaller number of facts. Where these further observations have led to different conclusions, the latter can only be legitimately overthrown, by proving that these observations are wrong, or by making still further ones in the several districts. It will be only a waste of time to reiterate old statements which have been thus tested and found wanting.

VI.—Fossil Types in the Bristol Museum.

By E. Wilson, F.G.S.;
Curator of the Bristol Museum.

Of "those precious specimens called 'types' which must be appealed to through all time to determine the species to which a name was originally given,"[1] Bristol Museum contains one hundred and eighty six distinct fossil forms. With the exception of a single Coal-measure plant, these are all the remains of animals, ranging in the zoological scale from the Reptilia to the Actinozoa, and stratigraphically from the Silurian to the Cretaceous epochs.

Many of these types possess for the student of British palæontology a very high interest, not only on account of the remarkable nature of the fossils themselves, but also from the fact of their having been described by some of the most distinguished of palæontologists. Amongst the "historic types" in the Bristol Museum may be specially noticed the following: The "types" described by Louis Agassiz in his great work the "Poissons Fossiles," comprising the teeth and fin-spines of Selachian fishes from the lower beds of the Carboniferous Limestone of the Avon Gorge near Bristol, the teeth of the original *Ceratodi* from the Rhætic "bone-bed" of Aust Cliff on Severn, and some interesting Jurassic fishes from various localities. The remarkable and indeed unique British series of reptilian remains derived from the Upper Triassic conglomerates fringing the Durdham Down at Redland, Bristol, originally described by Messrs. Riley and Stutchbury in the Transactions, and also more recently by Huxley in the Quarterly Journal of the Geological Society of London, under the generic names *Thecodontosaurus* and *Palæosaurus*, but in regard to which we have yet much to learn. And a considerable portion of the Mollusca, etc., from the Upper Greensand of Blackdown, Devon, described by James de Carle Sowerby in Dr. Fitton's Memoir "On the Strata between the Chalk and the Oxford Oolite in the South-east of England."

Of the "fossil types" in the Bristol Museum which have been determined in more recent years may be mentioned: That remarkably rich and varied series of the teeth of *Ceratodus*, 350 in number, collected from the Rhætic "bone-bed" of Aust Cliff by the indefatigable Higgins, and acquired for this Museum through the liberality of a number of friends and patrons of the Institution in the year 1873; the Inferior Oolite Gasteropoda from Dundry and Dorsetshire, so admirably described by the late Mr. E. B. Tawney, a former Curator of this Museum, in the Proceedings of the Bristol Naturalists' Society; a series of Inferior Oolite Pelecypoda ably described by the Rev. G. F. Whidborne; and a series of Upper Silurian Mollusca from Rhymney, near Cardiff, by Professor W. J. Sollas, in the Quarterly Journal of the Geological Society.

[1] W. H. Flower, LL.D., F.R.S., Presidential Address to the British Association for the Advancement of Science, Newcastle, 1889.

In Bristol Museum also are preserved the type-specimens of some of the Enaliosaurian reptiles, which have at different times been described by Owen, Stutchbury, Sollas and Lydekker, a small number of the molluscan types of James Sowerby, Stutchbury, and Hudleston, and a few Brachiopods of Davidson and Crinoids of Austen.

The plan adopted in this Catalogue will be as follows: the types from rocks of all ages will be arranged under their zoological classes in alphabetical order. Actual "types" only will be quoted in the first list, but to this there is appended a list of described and figured specimens in this Museum which are not original types.[1] The names —generic and specific—*originally* applied will in all cases be given in the leading place, the intention being to furnish a complete record of the fossil types in this Museum under their *original* names. When, however, owing to the progress of palæontological knowledge, the name either of the genus or of the species has been changed, or when the advisability of retaining the original or a later name has been questioned, such later names will also be given, the name here adopted coming last. No new revision will be attempted in this list, but a few names, generic and specific, which are now for the first time queried, will be placed in inverted commas, and certain obvious rectifications will be made, and doubtful points considered, especially in relation to the horizons and localities from which certain of these type-specimens have been derived.

The individual type-specimens only, which are at the present time in the Bristol Museum, will be specified, and the anatomical nature of these will be indicated. Thus the Catalogue will show exactly which of the original type-specimens are, and which are not now in this Museum,[2] and also of what these consist. The original reference to every type-species will be given, and the more important of the later references, where modifications in the original nomenclature have been proposed, or which are considered of special value in corroboration of same, but a detailed "synonymy" is not attempted. In regard to the described specimens, as a general rule, only "described and figured specimens" will be noticed, and references will be given only to the works where such specimens are described. A list of the principal works which relate to the fossil type and described specimens in the Bristol Museum is appended.

Reptilia.

Ichthyosaurus Conybeari, R. Lydekker. Geol. Mag. Dec. III. Vol. V. (1888), p. 311, and Cat. Foss. Rept. B.M. (1889), p. 53 [skeleton]. L. Lias, loc. doubtful.

Note.—In the British Museum Catalogue (*op. cit.*) the original specimen, on a cast of which this type was founded, is stated to have

[1] In the Bristol Museum, the type-specimens are indicated by a little disc of yellow paper marked Typ., and described specimens other than types by a similar disc of green paper marked Des.

[2] It is unfortunately the fact that certain type-specimens have disappeared from the Bristol Museum.

come from "Saltford, near Bath," but in an old Bristol Museum Catalogue it is given as from "Banwell, Somerset."

Ichthyosaurus latimanus, R. Owen, Rep. Brit. Assoc. for 1839 (1840), p. 123 [? two skeletons]. L. Lias, Banwell, Somerset.

NOTE.—According to Lydekker, *loc. cit.*, this type of Owen's was founded upon two specimens in the Bristol Museum, one of which is an example of *Ich. communis*, Conybeare, whilst the other is the type of *Ich. Conybeari*, Lydekker, *vide supra*.

Ichthyosaurus ? thyreospondylus, R. Owen, Rep. Brit. Assoc. for 1839 (1840), p. 124; J. Phillips, Geol. of Oxford, p. 307; ? *Ich. thyreospondylus*, Phillips (ex Owen); R. Lydekker, Cat. Foss. Rept. B.M. pt. ii. p. 34 [17 detached vertebræ]. Form. and loc. doubtful.

NOTE.—In an old Bristol Museum Catalogue these vertebræ are stated to have come from the "Lower Lias of Lyme Regis," but Phillips, *loc. cit.*, suggests that the type-specimens were derived from the "Kimmeridge Clay of Weymouth," where this form is not uncommon. This latter view seems probable, and it may be mentioned that there is an entire absence of the usual characteristic Liassic matrix adhering to these vertebræ.

Palæosaurus cylindrodon, H. Riley and S. Stutchbury. Trans. Geol. Soc. ser. ii. vol. v. p. 352, pl. xxix. f. 4; R. Owen, Palæontology, 2nd ed. p. 276 (*P. cylindricum*, Proc. Geol. Soc. vol. ii. p. 397); T. H. Huxley, Q.J.G.S. vol. xxvi. p. 43, pt. iii. f. 3 [fragmentary tooth]. U. Trias (dolomitic conglom.), Redland, Bristol.

Palæosaurus platyodon, H. Riley and S. Stutchbury, Trans. Geol. Soc. ser. ii. vol. v. p. 352, pl. xxix. f. 5, and Proc. Geol. Soc. vol. ii. p. 397; *Thecodontosaurus*, T. H. Huxley, Q. J. G. S. vol. xxvi. p. 43, pl. iii. fs. 1, 2, 5-8; R. Lydekker, Cat. Foss. Rept. B.M. pt. i. p. 174, f. 20 [tooth]. U. Trias (dolom. conglom.), Redland, Bristol.

Plesiosaurus brachycephalus, R. Owen, Rep. Brit. Assoc. for 1839 (1840), p. 69; syn. (adult form) of *Pl. macrocephalus*, Owen (ex Conybeare), R. Lydekker, Cat. Foss. Rept. B.M. pt. ii. p. 266 [skeleton]. L. Lias, Bitton, Gloucestershire.

Plesiosaurus Conybeari, W. J. Sollas, Q. J. Geol. Soc. vol. xxxvii. p. 440, pl. xxiii. and pl. xxiv. [skeleton, with casts of dorsal vertebræ and skull]. L. Lias, Charmouth.

Plesiosaurus costatus, R. Owen, Rep. Brit. Assoc. for 1839 (1840), p. 80; R. Lydekker, Cat. Foss. Rept. B.M. pt. ii. p. 282 [anterior cervical vertebræ]. ? Rhætic (bone bed), Aust Cliff.

Plesiosaurus megacephalus, S. Stutchbury, Q. J. Geol. Soc, vol. ii. p. 411, pl. xviii.; W. J. Sollas, Q.J.G.S. vol. xxxvii. p. 472; *Thaumatosaurus*, R. Lydekker, Cat. Foss. Rept. B.M. pt. ii. p. 166 [skeleton]. L. Lias, Street, Somerset.

Plesiosaurus rugosus, R. Owen, Rep. Brit. Assoc. for 1839 (1840), p. 82; *Eretmosaurus*, R. Lydekker, Cat. Foss. Rept. B.M. pt. ii. p. 249 [vertebræ]. Rhætic or ? "L. Lias," Aust Cliff.

Plesiosaurus subtrigonus, R. Owen, Rep. Brit. Assoc. for 1839 (1840), p. 77 [vertebræ]. L. Lias, Weston, near Bath.

Thecodontosaurus antiquus, J. Morris, Cat. Brit. Foss. 1st ed. p. 211, 2nd ed. p. 354; R. Owen, Palæontology, 2nd ed. p. 275; R. Lydekker, Cat. Foss. Rept. B.M. pt. i. p. 175; *Thecodontosaurus*, sp., H. Riley and S. Stutchbury, Trans. Geol. Soc. ser. ii. vol. v. p. 349, pl. xxix. fs. 1-3; T. H. Huxley, Q J.G.S. vol. xxvi. p. 43, pl. iii. fs. 1, 2 [left ramus of mandible with teeth]. U. Trias (dolom. conglom.), Redland, Bristol.

NOTE.—The types of the genera *Thecodontosaurus* and *Palæosaurus* in this Museum were founded on teeth, but associated with these teeth are numerous bones—vertebræ, ribs, pelvic, and limb-bones—many of which were described and figured by Riley and Stutchbury, and a few by Huxley. In two cases in the Bristol Museum, with many other undescribed bones, most if not all of these will be found; I have identified the following; Riley and Stutch., *op. cit.*, pl. xxix. fs. 1, 4, 5, 6, 7, 8, 9, 10, 11; pl. xxx. fs. 1, 2, 3, 5, 6, 8, 9, 10, 11; Huxley, *op. cit.* pl. iii. fs. 1, 2, 3, 5, 6.

Pisces.

Acrodus leiopleurus, L. Agassiz, Poiss. Foss. vol. iii. p. 145, pl. xxii. f. 5; A. S. Woodward, Geol. Mag. Dec. III. Vol. IV. (1887), p. 102, and Cat. Foss. Fish. B.M. pt. i. p. 295 [tooth]. ? Forest marble, ? loc. ? Gloucestershire.

Acrodus minimus, L. Agassiz, Poiss. Foss. vol. iii. p. 145, pl. xxii. fs. 6, 10; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 282 [teeth]. Rhætic (bone bed), Aust Cliff.

Acrodus nobilis, L. Agassiz, Poiss. Foss. vol. iii. pp. 140, 144, pl. xxi.; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 283 [incomplete dentition]. L. Lias, Lyme Regis.

? *Asteracanthus* "*Stutchburyi*," L. Agassiz, Poiss. Foss. vol. iii. p. 177 (name only). Syn. of *Ast. verrucosus*, P. M. G. Egerton, Ann. Mag. Nat. Hist. 2nd ser. vol. xiii. (1854), p. 433; Brit. Org. Rem. Mem. Geol. Surv. dec. viii. pl. ii. [dorsal spine]. Form. and loc. unknown.

Note.—For want of any figure or description in the "Poissons Fossiles," it is not certain, although it appears highly probable, that the above was Agassiz's MS. type. Mr. A. S. Woodward considers this specimen as probably synonymous with *Ast. verrucosus*, Egerton, which in the above-mentioned event must therefore replace Agassiz's name. The specimen in the Bristol Museum is labelled "Charmouth," and is stated in an old catalogue to have come from the "Lias" of that place. The slab of stone on which this spine rests is a very dense grey shelly limestone; certainly not Liassic. Tawney considered it to be Purbeck, and in connexion with this it may be observed that *Ast. verrucosus* is a Purbeck type, and according to Sir Philip Egerton is not uncommon in the Purbeck of Swanage and the neighbourhood.

Ceratodus altus, L. Agassiz, Poiss. Foss. vol. iii. p. 130, pl. xx. fs. 2-5: *C. polymorphus*, L. C. Miall, Siren. and Crossopt. Ganoids, p. 28; syn. of *C. latissimus*, Agass. (*op. cit.* vol. iii. p. 131), A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 26 [tooth]. Rhætic (bone bed), Aust Cliff.

Ceratodus curvus, L. Agassiz, Poiss. Foss. vol. iii. p. 131, pl. xx. f. 10; *C. polymorphus*, L. C. Miall, Siren. and Crossopt. Ganoids, p. 28; syn. of *C. latissimus*, Agass., A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 26 [tooth]. Rhætic (bone bed), Aust Cliff.

Ceratodus emarginatus, L. Agassiz, Poiss. Foss. vol. iii. p. 133, pl. xx. f. 11; *C. polymorphus*, L. C. Miall, Siren. and Crossopt. Ganoids, p. 28; syn. of *C. latissimus*, Agass., A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 27 [tooth], Rhætic (bone bed), Aust Cliff.

Ceratodus latissimus, L. Agassiz, Poiss. Foss. vol. iii. p. 131, pl. xx. fs. 8, 9; *C. polymorphus*, L. C. Miall, Siren. and Crossopt. Ganoids, p. 28; *C. latissimus*, Agass., A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 26 [two teeth]. Rhætic (bone bed), Aust Cliff.

Ceratodus parvus, L. Agassiz, Poiss. Foss. vol. iii. p. 132, pl. xx. f. 1; L. C. Miall, Siren. and Crossopt. Ganoids, p. 29, pl. v. fs. 4, ? 8, ? 9, 10; A. S. Woodward and C. D. Sherborn, Brit, Foss. Vert. p. 27 [tooth]. Rhætic (bone bed), Aust Cliff.

Ceratodus planus, L. Agassiz, Poiss. Foss. vol. iii. p. 132, pl. xx. fs. 6, 7; *C. polymorphus*, L. C. Miall, Siren. and Crossopt. Ganoids, p. 28; syn. of *C. latissimus*, Agass., A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 27 [tooth]. Rhætic (bone bed), Aust Cliff.

Ceratodus polymorphus, L. C. Miall, Siren. and Crossopt. Ganoids, p. 28, pl. ii. fs. 1-13; pl. iii. fs. 1 *a*, *b*, *c*, 2, 5 *a*, *b*, *c* pl. iv. fs. 1-11, pl. v. fs. 1 *a*, *b*; syn. of *C. latissimus*, Agass., A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 27 [numerous teeth]. Rhætic (bone bed), Aust Cliff.

Chalazacanthus verrucosus, J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 371, pl. xlviii. f. 13 [fin spine]. Carb. Limest. (black rock), Avon Gorge, Clifton, near Bristol.

Chomatodus (*Psammodus*) *cinctus*, L. Agassiz, Poiss. Foss. vol. iii. p. 107, pl. xv. fs. 13, 15, 16, 17. Undetermined anterior teeth of Cochliodont Sharks, A. S. Woodward, Cat. Foss. Fish. B. M. pt. i. p. 218 [teeth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Chomatodus (*Psammodus*) *linearis*, L. Agassiz, Poiss. Foss. vol. iii. p. 108, pl. xii. fs. 5, 7—13. *Petalodus* (*Chomatodus*) *linearis*, Agass., A. S. Woodward, Cat. Foss. Fish. B. M. pt. i. p. 45, as to specimens, fs. ? 5, 9, 10, ? 11 (*supra*); *Helodus expansus*, J. W. Davis, Scient. Trans. Roy. Dublin, Soc. vol. i. ser. ii. p. 457, as to specimens, fs. 7, 8, 12, 13 (*supra*), [teeth]. Carb. Limest. (black rock), and L. Limest. Shales (bone bed), Avon Gorge, Clifton.

NOTE.—The specimens fs. 9 and 10 *supra* are from the L. L. Shales, fs. 7, 8, 12, 13, from the Carb. Limest.

Cladodus Milleri, L. Agassiz, Poiss. Foss. vol. iii. p. 199, pl. xxii*b*. f. 22; syn. of *Cladodus mirabilis*, Agass., A. S. Woodward, Cat. Foss. Fish. B. M. pt. i. p. 16 [tooth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Cochliodus (*Psammodus*) *contortus*, L. Agassiz. Poiss. Foss. vol. iii. p. 115, pl. xiv. f. 22, and fs. 24, 27, 33; (pars) syn. of *Tomodus convexus*, Agass. MS., J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 446, as to f. 24 (*supra*), A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 191; (pars) syn. of *Deltoptychius gibberulus*, Agass. MS. J. W. Davis, op. cit. p. 435, as to f. 33 (*supra*); A. S. Woodward, op. cit. p. 214; (pars) syn. of *Psephodus*, sp. as to f. 22 (*supra*) [teeth]. Millstone Grit, Honeypen Quarry, Brandon Hill, Bristol. Carb. Limest. Avon Gorge, Clifton.

NOTE.—Specimen f. 22 is from the Millstone Grit, the remainder from the Carb. Limest.

Ctenacanthus brevis, L. Agassiz, Poiss. Foss. vol. iii. p. 11, pl. ii. f. 2; J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 337 [dorsal spine]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Ctenacanthus major, L. Agassiz, Poiss. Foss. vol. iii. p. 10, pl. iv. fs. 1, 2; J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 334 [dorsal spine]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Cyclarthrus macropterus, L. Agassiz, Poiss. Foss. vol. iii. p. 382, pl. xliv. f. 1; *Tectospondyli incertæ sedis*, A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 156 [fragments of pectoral fin]. L. Lias, Lyme Regis.

Gyronchus oblongus, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 202. pl. lxix*a*. fs. 10, 11; *Mesodon*, K. A. von Zittel, Handb. Palæont. vol. iii. (1889), p. 247; A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 120 [vomer]. Stonesfield Slate, Stonesfield.

NOTE.—In Morris's Cat. British Fossils, 2nd ed. p. 344, we find the following:—"*Scaphodus*, Agassiz, 1845? *Gyronchus*, Agassiz; *heteromorphus*, Ag., Bristol Museum, Gr. O. Stonesfield." The type specimen of *Gyronchus oblongus*, Agass., in the Bristol Museum was formerly labelled *Scaphodus heteromorphus*, Ag., and this was evidently the origin of the above. In the "Poissons Fossiles" I find no reference to any such form as *Scaphodus heteromorphus*, and know nothing of any such name, nor any authority for considering it synonymous with *Gyronchus oblongus*, Agass.

Helodus (*Psammodus*) *gibberulus*, L. Agassiz, Poiss. Foss. vol. iii. p. 106, pl. xii. f. 1; A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 93; undetermined anterior teeth of Cochliodontidæ, A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 219 [teeth]. Carb. Limest. Avon Gorge, Clifton.

Helodus (*Psammodus*) *lævissimus*, L. Agassiz, Poiss. Foss. vol. iii. p. 104, pl. xiv. fs. 8. 11, 13, 14, 15; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 181. *Psephodus* as to fs. 8, 11, 13, 14, ? *Tomodus* as to f. 15 [teeth]. L. Limest. Shales (bone bed), Avon Gorge, Clifton.

Helodus (*Psammodus*) *subteres*, L. Agassiz, Poiss. Foss. vol. iii. p. 105, pl. xii. f. 4; *Orodus*, J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 399, pl. i. f. 15; syn. of *Orodus ramosus*, Agass., "a much abraded tooth," A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 231 [tooth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Helodus (*Psammodus*) *turgidus*, L. Agassiz, Poiss. Foss. vol. iii. p. 106, pl. xv. fs. 5-12; A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 95;

undetermined anterior teeth of *Cochliodontidæ*, A. S. Woodward, Cat. Foss Fish, B.M. pt. i. p. 218 [teeth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Hybodus apicalis, L. Agassiz, Poiss. Foss. vol. iii. p. 43, pl. x. f. 22; non *Hybodus apicalis*, Agass. op. cit. vol. iii. p. 195, pl. xxiii. fs. 16–20; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 301 [dorsal spine]. Stonesfield Slate, Stonesfield.

Hybodus curtus, L. Agassiz, Poiss. Foss. vol. iii. p. 49 (described but not figured), (pars); syn. of *Acrodus Anningiæ*, Agass., E. C. H. Day, Geol. Mag. Vol. I. (1864), p. 57; A. S. Woodward, Cat. Foss. B.M. pt. i. p. 289 [dorsal spine]. L. Lias, Keynsham, Gloucestershire.

Hybodus leptodus, L. Agassiz, Poiss. Foss. vol. iii. p. 44, pl. x. fs. 2, 3 [imperfect dorsal spine]. Form. and loc. unknown.

Note.—This specimen is placed amongst the Lower Lias fishes.

Hybodus minor, L. Agassiz, Poiss. Foss. vol. iii. p. 48, pl. viii*b*. fs. 2, 3; *H. ? minor*, Agass., A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 102 [dorsal spine]. Rhætic, Pyrton Passage, Gloucestershire.

Hybodus raricostatus, L. Agassiz, Poiss. Foss. vol. iii. p. 187, pl. xxiv. f. 24; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 257 [tooth]. Form. (Lias or Rhætic) and loc. unknown.

Hybodus reticulatus, L. Agassiz, Poiss. Foss. vol. iii. p. 50, pl. ix. f. 5 (pars); A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 266 [dorsal spine]. L. Lias, Keynsham, Gloucestershire.

Legnonotus Cothamensis, P. M. G. Egerton, Brit. Org. Rem., Mem. Geol. Surv. dec. viii. pl. vii. fs. 9, 10, pl. vii. f. 11 [imperfect head and posterior portion of trunk with dorsal and caudal fins]. Rhætic (Cotham marble), Aust Cliff, Gloucestershire.

Myriacanthus paradoxus, L. Agassiz, Poiss. Foss. vol. iii. p. 38, pl. vi. f. 6 [dorsal spine]. L. Lias, Lyme Regis.

Nemacanthus filifer, L. Agassiz, Poiss. Foss. vol. iii. p. 26, pl. vii. f. 9; syn. of *N. monilifer*, Agass., J. W. Davis, Q.J.G.S. vol. xxxvii. p. 418; A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 126 [dorsal spine]. Rhætic (bone bed), Aust Cliff.

Nemacanthus monilifer, L. Agassiz, Poiss. Foss. vol. iii. p. 26, pl. vii. fs. 10, 11 [two dorsal spines]. Rhætic, Aust Cliff.

Onchus hamatus, L. Agassiz, Poiss. Foss. vol. iii. p. 9, pl. i. f. 7; *Physonemus*, J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 370; A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 149 [polished section of fin spine]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Oracanthus Milleri, L. Agassiz, Poiss. Foss. vol. iii. p. 13, pl. iii. fs. 1, 2 [dorsal spine and natural cast of same]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Oracanthus minor, L. Agassiz, Poiss. Foss. vol. iii. p. 16, pl. iii. f. 5; syn. of *O. Milleri*, Agass. J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 528; A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 132 [fragment of dorsal spine]. Carb. Limest., Avon Gorge, Clifton.

Note.—Mr. Davis, loc. cit., erroneously states the type-specimen of *Oracanthus minor*, Agass., to be in the "Jones Collection" of the Geological Society at Burlington House.

Oracanthus pustulosus, L. Agassiz, Poiss. Foss. vol. iii. p. 9, pl. i. f. 7 [dorsal spine]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Orodus cinctus, L. Agassiz, Poiss. Foss. vol. iii. p. 96, pl. xi. fs. 1, 4; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 230 [teeth]. L. Limest. Shales (bone bed), Avon Gorge, Clifton.

Orodus ramosus, L. Agassiz, Poiss. Foss. vol. iii. p. 97, pl. xi. fs. 5, 8, 9; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 231 [teeth]. Carb. Limest., Avon Gorge, Clifton.

Orodus sculptus, J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 396, pl. li. f. 8; A. S. Woodward, Cat. Foss. Fish. pt. i. p. 238 [tooth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Pholidophorus Higginsi, P. M. G. Egerton (ex Stutchbury, MS. Ann. Mag. Nat. Hist. ser. ii. vol. xiii. (1854), p. 435), Brit. Org. Rem., Mem. Geol. Surv. dec. viii. pl. vii. f. 6 [part of trunk]. Rhætic (Cotham marble), Aust Cliff.

Psammodus porosus, L. Agassiz, Poiss. Foss. vol. iii. p. 112, pl. xiii. fs. 1, 3, 5, 8, 9, 12, 14, 15, 18; syn. of *Ps. rugosus*, Agass., J. W. Davis, Scient. Trans. Roy.

Dublin Soc. vol. i. ser. ii. p. 459; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 100 [abraded teeth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Psammodus rugosus, L. Agassiz, Poiss. Foss. vol. iii. p. 111, pl. xii. f. 14; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 100 [teeth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Pycnodus ovalis, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 195, pl. lxxii. f. 5; syn. of *Mesodon* (*Pycnodus*) *Bucklandi*, Agass., op. cit. p. 192; A. S. Woodward, Geol. Mag. Dec. III. Vol. VI. (1889), p. 454 [vomer]. Stonesfield Slate, Stonesfield.

Sandalodus Morrisii, J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 437, pl. liv. fs. 1, 2; A. S. Woodward, Cat. Foss. Fish. B.M. pt. i. p. 185 [two teeth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Saurichthys acuminatus, L. Agassiz, Poiss. Foss. vol. ii. pt. ii. p. 85, pl. lv*a*. fs. 1-5 [teeth]. Rhætic, Aust Cliff.

Squaloraja [*Spinachorhinus*] *polyspondyla*, L. Agassiz, Poiss. Foss. vol. iii. p. 381, pl. xlii.; *Squaloraia*, H. Riley, Trans. Geol. Soc. ser. ii. vol. v. p. 83, pl. iv. [imperfect skeleton with traces of integument and dermal scutes]. L. Lias, Lyme Regis.

Tetragonolepis monilifer, L. Agassiz, Poiss. Foss. vol. ii. pt. i. p. 212, pl. xxi*a*. f. 2; *Dapedius*, J. Morris, Cat. Brit. Foss. 2nd ed. p. 324; A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 59 [body with portion of head]. L. Lias, Banwell, Somerset.

Cephalopoda.

Ammonites Sowerbyi, J. S. Miller, J. Sowerby, Min. Conch. pl. 213 [shell and natural cast]. Inf. Ool., Dundry.

Belemnites ellipticus, J. S. Miller, Trans. Geol. Soc. ser. ii. vol. ii. p. 60, pl. viii. fs. 14-16; J. Phillips, British Belemnitidæ, Pal. Soc. p. 97, pl. xxi. f. 53; syn. of *Bel. giganteus*, Schlotheim, Taschenb. 7, p. 70, and Petref. p. 45, no. 1, etc.; A. d'Orbigny, Pal. Franç. Terr. Jur. vol. i. p. 112 [guard with phragmacone]. Inf. Ool., Dundry.

Belemnites insculptus, J. Phillips, British Belemnitidæ, Pal. Soc. p. 45 (pars) [longitudinal section of guard and phragmacone]. L. Lias, Lyme Regis.

Hamites spinulosus, J. de C. Sowerby, Min. Conch. pl. 216, f. 1 (*Dentalium*, Miller, MS. Cat.); syn. of *Toxoceras Emericianus*, d'Orb., W. Downes, Q.J.G.S. vol. xxxviii. p. 90. Upper Greensand, Blackdown.

Gasteropoda.

Alaria angusta, W. H. Hudleston, Inf. Ool. Gast. Pal. Soc. 1888, p. 111, pl. iv. f. 2. Inf. Ool. ? loc.

Alaria Dundriensis, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 20, pl. i. f. 5; W. H. Hudleston, Inf. Ool. Gast. Pal. Soc. 1888, p. 122, pl. v. f. 2. Inf. Ool. Dundry.

Alaria Etheridgii, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 22, pl. i. f. 7; *Pseudalaria*, W. H. Hudleston, Inf. Ool. Gast. Pal. Soc. 1888, p. 189. Inf. Ool. near Yeovil.

Alaria trinitatis, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 20, pl. i. f. 6; *Spinigera*, W. H. Hudleston, Inf. Ool. Gast. Pal. Soc. 1888, p. 103. Inf. Ool. Dundry.

Bellerophon dilatatus, J. de C. Sowerby, R. I. Murchison, "Silurian System," p. 627, pl. xii. f. 24 [shell divided vertically into two halves]. Up. Sil. Aymestry.

Cirrus Leachii, J. de C. Sowerby, Min. Con. pl. 219, f. 3. Inf. Ool. Coker, near Yeovil.

Cirrus nodosus, J. Sowerby, Min. Conch. pl. 219, fs. 1, 3; E. B. Tawney, Dundry Gast. p. 36. Inf. Ool. Dundry.

Note.—This type is now identified for the first time.

Cirrus pyramidalis, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 37, pl. ii. f. 10. Inf. Ool. Dundry.

Cyclonema angulatum, W. J. Sollas, Q. J. Geol. Soc. vol. xxxv. p. 498, pl. xxiv. f. 5. Wenlock, Pen-y-lan, Cardiff.

Cyclonema simplex, W. J. Sollas, Q. J. Geol. Soc. vol. xxxv. p. 498, pl. xxiv. fs. 10, 10*a*. Wenlock, Rhymney River, Cardiff.

Euspira (*Natica*) *Dundriensis*, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 15, pl. i. f. 3. Inf. Ool., Dundry.

Fusus clathratus, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 344, pl. xviii. f. 19; ? *Rapa*, F. Stoliczka, Cret. Gast. of S. India, p. 148. Up. Greensand, Blackdown.

Fusus quadratus, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 17; *Murex*, J. Sowerby, Min. Conch. pl. 410, f. 1 (young). Up. Greensand, Blackdown.
Fusus rigidus, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii, f. 16. Upper Greensand, Blackdown.
Fusus rusticus, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 344, pl. xviii. f. 18 (non *Fusus rusticus*, D'Orb.). Up. Greensand, Blackdown.
Holopella gracilis, W. J. Sollas, Q. J. Geol. Soc. vol. xxxv. p. 498, pl. xxiv. f. 5 [two casts in gutta percha and sealing wax]. Wenlock, Rhymney, Cardiff.
Holopella hydropica, W. J. Sollas, Q. J. Geol. Soc. vol. xxxv. p. 498, pl. xxiv. f. 4 [the original mould and two casts in gutta percha]. Wenlock, Rhymney, Cardiff.
Holopella minuta, W. J. Sollas, Q. J. Geol. Soc. vol. xxxv. p. 498, pl. xxiv. f. 6 [cast in sealing wax]. Wenlock, Rhymney, Cardiff.
Littorina gracilis, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 12; *Cerithium* (*Sandbergeria*), F. Stoliczka, Cret. Gast. of S. India, p. 264; *Cerithium*, W. Downes, Q.J.G.S. vol. xxxviii. p. 89. Up. Greensand, Blackdown.
Littorina pungens, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 5; *Phasianella*, W. Downes, Q.J.G.S. vol. xxxviii. p. 89. Up. Greensand, Blackdown.
"*Littorina*" *recteplanata*, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 24, pl. ii. f. 6. Inf. Ool. Dundry.
Murchisonia corpulenta, W. J. Sollas, Q.J.G.S. vol. xxxv. p. 499, pl. xxiv. f. 11. Wenlock, Rhymney, Cardiff.
Murchisonia elegans, W. J. Sollas, Q.J.G.S. vol. xxxv. p. 499, pl. xxiv. f. 8. [One natural mould, and two casts in gutta percha and sealing wax.] Wenlock, Rhymney, Cardiff.
Nassa costellata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 344, pl. xviii. f. 26; *Cerithium*, d'Orbigny, Prod. vol. ii. p. 156; *Cerithium* (probably), F. Stoliczka, Cret. Gast. of S. India, p. 143. Up. Greensand, Blackdown.
Natica canaliculata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 6. Up. Greensand, Blackdown.
Natica carinata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii, f. 8; ? *Fossar*, F. Stoliczka, Cret. Gast. of S. India, p. 261; *Fossarus*, W. Downes, Q.J.G.S. vol. xxxviii. p. 89. Up. Greensand, Blackdown.
"*Nerita*" *lævigata*, J. Sowerby, Min. Conch. pl. 217, f. 1; *Monodonta*, J. Lycett, Proc. Cotts. Nat. Field Club, vol. i. p. 77; E. B. Tawney, Dundry Gast. p. 34; W. H. Hudleston, GEOL. MAG. Dec. III. Vol. II. (1885), p. 52. Inf. Ool., Dundry.
Phasianella formosa, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 14; *Actæon* (probably), F. Stoliczka, Cret. Gast. of S. India, p. 409. Up. Greensand, Blackdown.
Phasianella striata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 15; *Actæon* (probably), F. Stoliczka, Cret. Gast. of S. India, p. 409. Up. Greensand, Blackdown.
Pleurotomaria distinguenda, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 45, pl. iii. f. 2. Inf. Ool. Dundry.
Pleurotomaria "*Dundriensis*," E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 46, pl. iii. f. 3. Inf. Ool. Dundry.
Pleurotomaria "*obconica*," E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 45, pl. iii. f. 6, Inf. Ool. Dundry.
Pleurotomaria "*Sandersii*," E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 39, pl. iii. f. 1. Inf. Ool. Dundry.
Pleurotomaria "*Stoddarti*," E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 50, pl. iii. f. 5. Inf. Ool. Dundry.
Purpurina inflata, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 12, pl. iii. f. 9; W. H. Hudleston, Inf. Ool. Gast. Pal. Soc. 1888, p. 92. Inf. Ool. Dundry.
Pyrula depressa, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 344, pl. xviii. f. 20; *Tudicla* or *Rapa*, F. Stoliczka, Cret. Gast. of S. India, p. 148. Up. Greensand, Blackdown.
Rostellaria macrostoma, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 344, pl. xviii. f. 23; *Aporrhais*, J. S. Gardner, GEOL. MAG. Dec. II. Vol. II. (1875), p. 291; *Pterocerella*, J. S. Gardner, GEOL. MAG. Dec. II. Vol. VII. (1880), p. 53; W. Downes, Q.J.G.S. vol. xxxviii. p. 89. Up. Greens. Blackd.
Rostellaria retusa, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 344, pl. xviii. f. 22; *Aporrhais*, J. S. Gardner, GEOL. MAG. Dec. II. Vol. II. p. 52. Up. Greensand, Blackdown.

Scalaria climaspira, J. S. Gardner, GEOL. MAG. Dec. II. Vol. III. p. 109, Pl. III. Fig. 13 (in part type). Up. Greensand, Blackdown.
Scalaria pulchra, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 11; J. S. Gardner, GEOL. MAG. Dec. II. Vol. III. p. 109. Up. Greensand, Blackdown.
"*Straparollus*" *Dundriensis*, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 35, pl. ii. f. 9. "*Discohelix*." Inf. Ool. Dundry.
Tornatella affinis, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 9; *Actæon*, d'Orbigny, Terr. Cret. ii. p. 117; *Ringinella*, Stoliczka, Cret. Gast. of S. India, p. 408. Up. Greensand, Blackdown.
Trochus Sandersii, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 31, pl. ii. f. 4. Inf. Ool. Dundry.
Trochus sulcatus, Jas. Sowerby (non Phillips). Min. Conch. pl. 220, f. 3; *Pleurotomaria*, E. B. Tawney, Dundry Gast. p. 43. Inf. Ool. Dundry.
Trochus Winwoodi, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 34, pl. ii. f. 8. Inf. Ool. Dundry.
"*Turbo*" *Dundriensis*, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 30, pl. ii. f. 2. "*Amberleya*." Inf. Ool. Dundry.
Turbo ornatus, J. Sowerby, Min. Conch. pl. 240, f. 1; *Amberleya*, E. B. Tawney, Dundry Gast. p. 27. Inf. Ool. Dundry.

NOTE.—This type is now identified for the first time.

Turbo Shaleri, E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 31, pl. ii. f. 3. Inf. Ool. Dundry.
Turbo "*Stoddarti*," E. B. Tawney, Proc. Brist. Nat. Soc. n.s. vol. i. p. 29, pl. ii. f. 1. Inf. Ool. Dundry.

PELECYPODA.

Ambonychia tumida, W. J. Sollas, Q.J.G.S. vol. xxxv. p. 497, pl. xxiv. f. 9 [right valve]. Wenlock, Pen-y-lan, Cardiff.
Amphidesma? tenuistriata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvi. f. 7; ? *Thracia* or *Tellina*, F. Stoliczka, Cret. Pel. of S. India, p. 111 [? left valve]. Up. Greensand, Blackdown.
Arca culmotecta, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 520, pl. xviii. fs. 1, 1*a* [left valve]. Inf. Ool. Dundry.
Arca rotundata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 8; *Barbatia*, F. Stoliczka, Cret. Pel. of S. India, p. 343 [right valve]. Up. Greensand, Blackdown.
Astarte concinna, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvi. f. 15; *Eriphyla*, F. Stoliczka, Cret. Pel. of S. India, p. 285 [left valve]. Up. Greensand, Blackdown.
Astarte formosa, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvi. f. 16; *Gouldia*, F. Stoliczka, Cret. Pel. of S. India, p. 285 [valves united]. Up. Greensand, Blackdown.
Astarte impolita, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvi. f. 18 [valves united]. Up. Greensand, Blackdown.
Avicula anomala, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 18; *Crenatula*, F. Stoliczka, Cret. Pel. of S. India, p. 398 [left valve]. Up. Greensand, Blackdown.
Cardinia (*Pachyodon*) *abducta*, S. Stutchbury, Ann. Mag. Nat. Hist. vol. viii. (1842), p. 484, pl. x. fs. 9, 10 [both valves]. Inf. Ool. Dundry.
Cardinia (*Pachyodon*) *attenuata*, S. Stutchbury, Ann. Mag. Nat. Hist. vol. viii. (1842) p. 485, pl. x. f. 13 [valves united and fragment of a left valve]. L. Lias, Battledown, Cheltenham.
Cardinia (*Pachyodon*) *crassiuscula*, S. Stutchbury, Ann. Mag. Nat Hist. vol. viii. p. 483, pl. ix. f. 8; syn. of *Unio crassiuscula*, J. Sowerby, Min. Conch. pl. 153 [left valve]. L. Lias, Langar, Notts.
Cardinia (*Pachyodon*) *cuneata*, S. Stutchbury, Ann. Mag. Nat Hist. vol. viii. p. 484, pl. x. fs. 11, 12; *C. Listeri*, var. *cuneata*, Morris, Cat. Brit. Fos. 2nd ed. p. 190 [valves united]. L. Lias, Gloucestershire.
Cardinia (*Pachyodon*) *imbricata*, S. Stutchbury, Ann. Mag. Nat. Hist. vol. viii. p. 483, pl. ix. fs. 5, 6; *C. Listeri*, var. *imbricata*, J. Morris, Cat. Brit. Foss. 2nd ed. p. 190 [right and left valves]. L. Lias, Gloucestershire.
Cardinia (*Pachyodon*) *ovalis*, S. Stutchbury (non Mantell), Ann. Mag. Nat. Hist. vol. viii. p. 485, pl. x. f. 19 [valves united]. L. Lias, Fretherne, Gloucestershire.
Cardium Dundriense, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 524, pl. xviii. f. 8 [? right valve]. Inf. Ool. Dundry.
Corbula truncata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341,

pl. xvi. f. 8 (non *Corbula truncata*, Sow., d'Orbigny, Terr. Cret. vol. iii. pl. 388, fs. 8-12) [right and left valves]. Up. Greensand, Blackdown.

Cucullæa formosa, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 7; W. Downes, Q.J.G.S. vol. xxxviii. p. 87 [left valves]. Up. Greensand, Blackdown.

Cypricardia filoptera, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 529, pl. xviii. fs. 19, 19*a* [valves united]. Inf. Ool. Dundry.

Cyprina rostrata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvii. f. 1; *Veniella* (*Venilicardia*), F. Stoliczka, Cret. Pel. of S. India, p. 193 [right valve]. Up. Greensand, Blackdown.

Cytherea subrotunda, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvii. f. 2; *Caryatis*, F. Stoliczka, Cret. Pel. of S. India, p. 161 [right valve]. Up. Greensand, Blackdown.

Gervillia gladiolus, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 516, pl. xvi. f. 7 [double shell] Inf. Ool. Dundry.

Gervillia rostrata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 17; ? *Perna*, J. Morris, Cat. Brit. Foss. 2nd ed. p. 179; *Melina*, F. Stoliczka, Cret. Pel. of S. India, p. 400 [valves united]. Up. Greens. Blackdn.

Gryphea abrupta, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 493, pl. xv. f. 7 [left valve]. Inf. Ool. Dundry.

Gryphea Sollasii, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 495, pl. xv. f. 9 [valves united]. Inf. Ool. Dundry.

Harpax Tawneyi, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 514, pl. xv. fs. 18, 19 [2 single valves in matrix showing interiors]. Inf. Ool. Dundry.

Leda ? ambigua, W. J. Sollas, Q.J.G.S. vol. xxxv. p. 497, pl. xxiv. f. 7 [valves united]. Up. Ludlow, Cae Castle, Rhymney.

Lima antiquata, J. Sowerby, Min. Conch. pl. 214, f. 2 [valves united]. Syn. of *L. succincta*, Schlotheim, R. Tate, York. Lias, p. 365. L. Lias, Fretherne, Gloucestershire.

Lima poetica, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 511, pl. xvii. f, 9 [left valve]. Inf. Ool. Dundry.

Lima subovalis, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 21; *Radula* (*Ctenoides*), F. Stoliczka, Cret. Pel. of S. India, p. 414 [valves united]. Up. Greensand, Blackdown.

Lucina ? orbicularis, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvi. f. 13; *Limopsis*, F. Stoliczka, Cret. Pel. of S. India, p. 252 [valves united]. Up. Greensand, Blackdown.

(*To be continued.*)

NOTICES OF MEMOIRS.

Le Pieghe delle Alpi Apuane. Contribuzione agli Studi sull' Origine delle Montagne. Per Carlo de Stefani, Professore di Geologia nel R. Istituto di Studi Superiori di Firenze. pp. 114. Con una Carta Geologica, due Tavole di Spaccati, ed Incisioni nel Testo. (Firenze, Le Monnier, 1889.)

The Foldings of the Apuan Alps. Contributions to the Study of the Origin of Mountains. By Prof. C. de Stefani. With coloured Geological Map, two Tables of Sections, and Woodcuts.

THE author of this work, who has for many years studied the Apuan Alps, commences by giving a description of the different beds of which they are composed and of the fossils contained in them. The lowest strata consist of dark magnesian limestones, with numerous remains of *Orthoceras*, Crinoids, and Sponges, which are referred on general grounds to the age of the Middle or Upper Silurian. These are succeeded by peculiar bluish, bituminous limestones, technically known as '*grezzoni*,' belonging to the Middle Trias or Muschelkalk, and above these, a series of limestones, marbles and schists of the age of the Upper Trias. In this series are included the famous statuary marbles of Carrara, and their true geological horizon, now no longer doubtful, was first determined by Prof. Stefani. Some of the limestones are in part siliceous, and there are also beds of red jasper, several mètres in thickness, which are regarded by the author as due to Radiolaria.

In places the limestones are mainly composed of Crinoidal remains, referred mostly to a single species, *Encrinus granulosus*, Münst. Following the Trias in upward succession are limestones of Rhætic or Infraliassic age; the Lower Trias, including the zones of *Psilonoti*, *Angulati* and *Arietites*; the Middle and Upper Lias; Jurassic schists with *Posidonomya ornati*, Quenst., which may probably represent the Oxford Clay; the Tithonian; Neocomian; Middle and Upper Chalk; Nummulitic limestones, clays and sands of Eocene age, represented also by serpentines, gabbros and diabases; gravels and clays of Upper Miocene age; Pliocene; Post-pliocene and Glacial deposits. References are given to the principal fossils present in these beds respectively, and they are briefly compared with synchronous deposits in other parts of Italy and elsewhere in Europe. The breaks or interruptions in this series are considered in a separate chapter, and this is followed by a table showing in a concise form the different successive zones and their characters.

No small part of the work is taken up by a detailed description of the various anticlinal and synclinal folds which form such marked features of the Apuan Alps, and the characters and course of these are well shown in the accompanying map and plates of sections. The author treats further of the displacements of beds which have been produced by foldings of the strata, and arrives at the conclusion that the greater part of these displacements does not result from an original discordance, but has been produced by movements in the beds themselves. He likewise opposes the view that the formation of the marbles and the *uralitization* of the Eocene diabases have been due to phenomena of compression, and attributes these alterations in the rocks to slow molecular changes produced or favoured by circulating waters and by the ordinary metamorphic surroundings. Jointings in the rocks, and the origin of valleys independently of faults, are likewise considered. Numerous instances are given of the partial inversion of strata which occur on the outer borders of mountain chains, which result from purely superficial phenomena, but may have nevertheless an important influence on the formation of these ranges.

The final chapter treats of the general conclusions on the origin of mountains, deduced from the Apuan Alps, but having a wider application. As the result of his observations, the author states that the secondary folds which constitute mountains are probably only the result of relatively subordinate phenomena which take effect at no great distance below the terrestrial surface, in the interior of greater and more general undulations, through compression produced by the overlying superficial strata; and in support of this view he refers to the paper of Mr. Charles Davison [1] 'On the Secular Straining of the Earth.'

[1] Geol. Mag. May, 1889, p. 220.

REVIEWS.

I.—Professor Gaudry on *Dryopithecus.*

A. Gaudry.—Le Dryopithèque. Mém. Soc. Géol. France, Paléontologie, vol. i. Mém. No. 1, pp. 11, pl. 1 (1890).

In this interesting and important communication the learned Professor of the Paris Museum brings to notice a nearly complete lower jaw, recently obtained from the Miocene of St. Gaudens, belonging to the large Anthropoid Ape known as *Dryopithecus.*

This Ape, it may be well to mention, was previously known mainly by a very imperfect lower jaw obtained many years ago from the same deposits, and described by the late Edouard Lartet. Owing to the imperfection of that specimen, it was considered that the Dryopitheque had an extremely short symphysis to the lower jaw, and consequently that it was more specialized, and came nearer the human type than any existing Ape. The comparatively early geological horizon in which the remains of this Ape are found rendered its presumed specialization a very remarkable circumstance.

The new specimen has, however, proved that the creature was, as might have been expected from *à priori* considerations, in reality the most generalized of all the Man-like Apes. This is, indeed, rendered very clear by the four lower jaws represented in the plate accompanying Prof. Gaudry's memoir; and it will be seen from these figures that there is a very gradual diminution in the length of the symphysis of the lower jaw as we pass from the Dropitheque to the Gorilla, Chimpanzee, and, finally, Man. The long symphysis of the fossil form allies it with the lower Baboons and Monkeys; and we thus see that the Dryopitheque now definitely takes that place in the family *Simiidæ* which we should have assigned to it from its geological horizon. The relegation of this Ape to a low position induces the Professor to withdraw his suggestion that the problematical facetted flints of the Miocene of Thénay were its handiwork. R. L.

II.—The Geology of the Country near Yarmouth and Lowestoft.

By J. H. Blake, F.G.S., etc. Geological Survey Memoir, 8vo. pp. 101. Price 2*s.* (London, Kegan Paul, Trench, Trübner & Co.)

A SKETCH of the Natural History of Yarmouth and its neighbourhood, by C. J. and [Sir] James Paget, was published in 1834. That work contains but a brief reference to the geology; for, excepting in some controversial papers on recent physical changes by J. W. Robberds and R. C. Taylor, the district had up to that time received but little attention from geologists. The interest of the geology is indeed to a large extent furnished by the cliff-sections of Kessingland, Pakefield, and Corton. Accounts of these were subsequently published by Trimmer, Gunn, Wood and Harmer, Prestwich, and others; and in 1884 a detailed section by Mr. Blake was published by the Geological Survey (see Geol. Mag. April, 1885, p. 180).

Mr. Blake now gives full particulars of all the strata exposed in the area, including also those, like the Chalk, Reading Beds and London Clay, which were identified by Prof. Prestwich from evidence obtained in a well-boring at Yarmouth. The cliffs exhibit the best sections we have in England of the "Chalky Boulder Clay," but the beds of most interest belong to the Forest Bed Series, and these are exposed at intervals along the base of the cliffs, being usually much obscured by talus.

Some notes on borings made along this coast are contributed by Mr. Clement Reid, and it is interesting to learn that traces of Crag were found below the base of the cliff at Pakefield. It seems likely also that some portion of the Crag Series is represented in the beds (120 feet thick) grouped as "Recent Estuarine Deposits" in Prof. Prestwich's record of the deep well at Yarmouth; but Mr. Blake expresses no opinion on this subject. These Estuarine deposits are surmounted by about fifty feet of Blown sand and shingle, on which the town of Yarmouth stands. The town indeed is built on an old sand-bank, which is supposed to have been isolated from the land until about A.D. 1000. A representation of this "popular tradition" is given in the Yarmouth Hutch Map, a copy of which was published by S. Woodward (History of Norwich Castle, p. 48); and Mr. Blake quotes Spelman, who says that this ground first became firm and habitable about the year 1008.

The Broads form a pleasing feature of the inland scenery. These, according to Mr. Blake, in all probability date back to the times when the main river-channels formed branches of an estuary. Tidal action then assisted in scouring out these shallow basins, and they were afterwards to some extent dammed up by bars that were formed across the outlets of the valleys in which they lie.

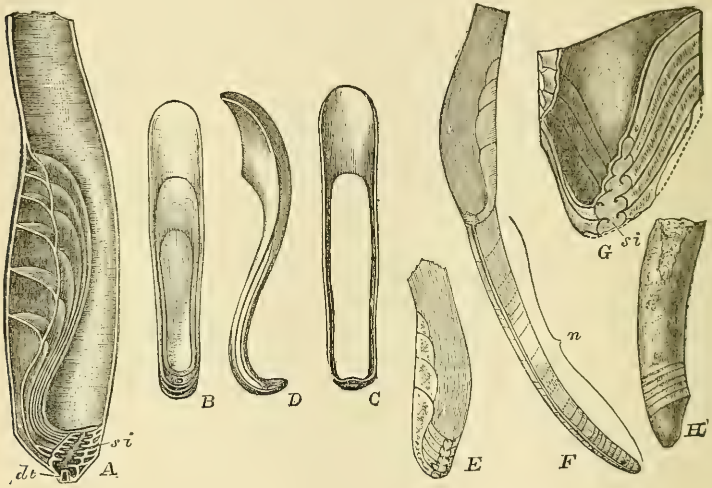
Appendices to this work include accounts of well-sections and borings, lists of fossils from the Forest Bed Series and from the Glacial Sands, and an account of the Lowestoft China, etc.

III.—The Ascoceratidæ and the Lituitidæ of the Upper Silurian Formation of Gotland. Described by G. Lindström. 40 pages and 7 plates. Communicated to the Royal Swedish Academy of Sciences, 11th December, 1889. (Stockholm, 1890.)[1]

So much of the work of the palæontologist of our day necessarily consists in revising that of his predecessors, that the appearance of a palæontological memoir, written by a master of the craft, and containing new facts and deductions, cannot fail to arouse more than ordinary interest. After long and patient research, Dr. Lindström has brought to light, from the rich Silurian deposits of Sweden, nearly the whole of the missing parts of the shell of *Ascoceras*. Though this discovery has been anticipated to some extent by the author in a paper communicated to this Magazine (December, 1888), we have in the present memoir a very complete and clear account of the structure of *Ascoceras*, and an allied new genus (*Choanoceras*) illustrated with a series of admirable plates, containing numerous figures.

[1] Written in English.

The memoir opens with an introduction, containing a description of the Cephalopoda beds of Gotland: these represent the "Ludlow beds" (190 feet), the "Wenlock shale" (80 feet), and the "Upper Llandovery" (thickness unknown). In the uppermost of these beds immense masses of the shells of Cephalopoda occur, the strata (4 or 5 feet thick) being made up almost entirely of them, in some places. From the vast quantities of these shells, of all sizes, thus heaped together, the author supposed that they were washed ashore, as the shells of *Spirula* are at the present day on the shores of the Pacific islands.



A, Schematic view of the interior of *Ascoceras manubrium*, Lindstr., showing the structure and arrangement of the septa; *si*, siphuncle; *dt*, duct that communicates with the siphuncle of the Nautiloid portion of the shell (see *n*, Fig. F); B, schematic view of three sigmoid septa of *Asc. fistula*, Lindstr., seen from the ventral side; C, view of the third septum of the same species, shown as free, as if removed from the shell, to exhibit the large central lacuna; D, the same viewed laterally (the siphuncular orifice is seen at the bottom of all these figures); E, longitudinal section of a specimen of *Asc. decipiens*, Lindstr., from Sandarfve Kulle, with four regular septa above the sigmoid ones; F, schematic view of *Asc. decipiens*, represented as if complete—*n*, the Nautiloid portion of the shell; G, longitudinal and median section from the concave to the convex side, of *Choanoceras mutabile*, Lindstr., showing the interior of the shell, with the outlines of the incomplete septa—*si*, siphuncle; H, fragment of the same species, reduced to about $\frac{1}{3}$ natural size. All the figures are copied from Lindström's plates A—D, reduced from $\frac{1}{3}$ to $\frac{1}{2}$ natural size; E—G are the same size as the original figures.

After reviewing in considerable detail the work done by various authors, chiefly German and Swedish, in connection with Gotland Cephalopoda, including Klein, Breynius, Hisinger, Schlotheim, Wahlenberg, Marklin, Angelin, Boll, and Barrande, Dr. Lindström commences his description of the Family Ascoceratidæ.[1] In this

[1] The fossils described in this memoir belong mostly, we are told, to the Palæontological Department of the Swedish State Museum at Stockholm.

family he recognizes four genera, viz. *Ascoceras*, Barrande,[1] *Glossoceras*, Barr.,[2] *Billingsites*, Hyatt,[3] and *Choanoceras*, gen. nov. These genera are united together by a structural feature common to all of them, viz. "the abnormal growth and morphology of the septa formed during the last stage of their existence." Beginning with regularly-formed septa, there are developed at a later stage of growth a series of septa which bend upwards in a sigmoid fashion against the walls of the shell, on the dorsal side. All the septa succeeding the first sigmoid one are incomplete, leaving a large "lacuna" or empty space (Figs. C, D) in the centre, which lacuna is bounded by the lateral margins of the septa. The siphuncle (Figs. A, G, *si*) is broad, with nummuloidal or bulbous elements. Truncation seems to have been repeated several times in all these genera.

Ascoceras.—This genus has two distinct stages in its development, viz. *a*, the Nautiloid; *b*, the Ascoceras proper. Stage *a* corresponds with the common type of the suborder Nautiloidea. It may be regarded, theoretically, as a long gently-curved tube (Fig. F), corresponding in curvature with the Ascoceras part of the shell; but owing to its having been broken off or decollated several times during growth its actual length seldom exceeds that of the Ascoceras portion, and it often falls short of this. The test of the Nautiloid stage (Fig. F, *n*) is generally transversely striated; sometimes annulated. The septa are oblique, shallowly concave, and higher on the dorsal than on the ventral side: they are irregularly spaced, sometimes several are placed near together, while others are wide apart. The necks of the septa[4] project backwards. The siphuncle is always situated near the ventral (convex) side; it is composed of slender, tubular elements.

The second stage of *Ascoceras*, termed by Lindström *Ascoceras proper*, is of sac- or flask-like form, slightly curved, with a narrow, cylindrical prolongation or neck, ending in a simple, circular aperture.

The internal structure requires a more detailed description, especially as Dr. Lindström's researches have revealed some new features in it. The septa are of two kinds: *a*, regular or Nautiloid septa; *b*, Sigmoid septa. The first septum, which may be regarded as the last Nautiloid septum, and forms the bottom of the shell, "is strengthened from within by organic deposits of calcareous matter." This septum is in some species followed by a second, of the ordinary shape; but in the majority of species the abnormal, sigmoid septa (Figs. A, E, F) immediately succeed the first, ordinary one. The number of sigmoid septa varies from three to seven; but

[1] Oesterr. Blätt. für Litt. u. Kunst, 1847; Haidinger's Berichte über d. Mittheil. v. Freund. d. Naturwiss. in Wien, 1847, p. 268; also Bull. Soc. Géol. France, 1855, sér. 2, vol. xii. p. 157.

[2] Syst. Sil. de la Bohême, 1867, vol. ii. pt. i. p. 372.

[3] "Genera of Fossil Cephalopods," Proceed. Boston Soc. Nat. Hist. vol. xxii. 1883, p. 278. *Billingsites* is a Silurian genus closely allied to *Ascoceras*. The type species is *Asc. Canadense*, Billings, Rep. Prog. Geol. Surv. Canada, 1853–56, p. 310.

[4] Their recurved ends which form a little funnel through which the siphuncle passes.

it is very constant in any given species.[1] The septa are continuous from the ventral (convex side) to the dorsal side, as may be seen in many of the casts,[2] where the sutures continue uninterruptedly across; in the interior of the shell, however, this continuity is broken. Here only the first sigmoid septum is entire, all the succeeding ones having a broad, elongate, elliptical empty space or lacuna, running longitudinally and slightly expanding anteriorly, in accordance with the increasing diameter of the shell (Figs. C, D). The organic deposition ceased where the septum touched the surface of the next preceding one, but the margins, where the septa were not in contact, are entire. The margins thus form a sort of frame around the central, elongated, empty space. The siphuncle (Fig. A, G, *si*), always near the ventral side of the shell, consists of broad, nummuloid elements; it is in immediate connexion with the siphuncle of the Nautiloid stage of the Ascoceras shell through a peculiar little tubular duct (Fig. A, *dt*), which is closed by a calcareous secretion, when decollation has taken place. The form and position of the septa (Fig. A) may be thus described. Starting from the dorsal wall of the shell they first make a strong, inwardly-directed curve, and then sweeping outwards in a wider curve, they closely approach the dorsal side, and finally bend round to the ventral side, thus completely encircling the shell.

Dr. Lindström considers it questionable whether there was any great change in the shape of the animal of *Ascoceras*, such as the altered form of the septa in the Ascoceras stage would lead one to suppose. That there was some change, at least in volume, he naturally infers, because it seems evident that the shell was, as it were, moulded upon the body of the animal. But he finds, in several instances, evidence of a curious reversion in the shape of the septa and siphuncle to the Nautiloid stage in the *Ascoceras*. Figure E exhibits this remarkable modification. Dr. Lindström argues from this "reversion of characters" that as the animal could scarcely "twice modify its body," there must actually have been very little change in its structure as it passed from the Nautiloid into the Ascoceras stage.

Referring to the increase in the size of the body of the animal of *Ascoceras*, as shown by the inflation of the sac-like part of its shell, Dr. Lindström remarks: "An increase in the volume of the body must also have occurred in such genera as *Gomphoceras* and *Poterioceras*, the latter of which bears no slight resemblance to *Ascoceras*. When the shell had been completed, the mollusc drew itself higher up in it and commenced the secretion of the sigmoid septa. Near the ventral side the place of the animal has not been much changed; at the dorsal, again, it moved more and more upwards."

A short history of *Ascoceras* here follows, in which the views of different authors, beginning with Barrande, are set forth and

[1] A fragment of an unknown species, figured by Dr. Lindström, has indications of no less than twelve septa.

[2] We observe that Dr. Lindström uses the term "nucleus," in the same sense; but it is scarcely so appropriate.

criticized. The author claims to be the first to have seen the "Nautiloid" portion of *Ascoceras*, and we think justly; for the specimen found in 1877 by Barrande (Syst. Sil. de la Bohême, vol. ii. Suppl. p. 98, pl. ccccxci.) with two septa beneath the first sigmoid one, regarded by him as deciduous septa, are, in fact, says Lindström, "the first two septa of the *Ascoceras*, and the lowermost of these is the truncated extremity."

The following (thirteen) new species of *Ascoceras* are described (pp. 20—33) and figured :—*cochleatum, dolium, fistula, pupa, reticulatum, manubrium, ampulla, collare, lagena, cucumis, decipiens, sipho, gradatum.* Besides these, *A. Bohemicum*, Barrande, is described and figured. Passing over *Glossoceras* and *Billingsites*, about which the author has nothing special to remark, we come to the new genus *Choanoceras*[1] (Figs. G, H) described as having a shell "resembling a faintly-curved Orthoceratite, with the lower extremity truncated and conically pointed." The aperture is probably simple; the body-chamber very large, occupying almost nine-tenths of the whole shell. Septa from four to six, formed like a pointed, oblique funnel. All the septa are equally well developed in young specimens, but in the adult, in which there are six septa, three of these are complete, and the three earlier ones incomplete or lacunose. The siphuncle is nummuloid in the older individuals, cylindrical in the younger, and the necks of the septa hook-like and strongly recurved. This genus contrasts with *Ascoceras* in the meagre development of its lacunose septa. The position of the latter may also be contrary to those in *Ascoceras*, supposing that the convex side of the shell is the ventral, and the concave the dorsal, as is assumed in *Ascoceras*. In *Choanoceras* the lacunose part of the septa is placed against the convex side; in *Ascoceras* near the concave side. One species of *Choanoceras* is described and figured, viz. *C. mutabile*.

A fragment of an unknown genus is figured by Dr. Lindström, who describes it as having "pointed and funnel-like septa; but regularly placed in the median axis of the straight shell." The necks of the septa are very long and continuous down to the bottom of the next septum, "thus forming, as it seems, the entire siphuncle." It cannot, therefore, belong to the present group.

Under the Lituitidæ, two species of *Ophidioceras* are described and figured, viz. *O. reticulatum*, Angelin, and *O. rota*, sp. nov. Of this genus Dr. Lindström observes that there is nothing to add to the generic characters given by previous authors, except that the body-chamber is of extreme length in all the Gotland specimens that have been sectioned. It occupies, namely, more than one whorl, and sometimes more than two.

Referring to the classification of the Ascoceratidæ and kindred groups, Dr. Lindström dissents from Hyatt's allocation of his (Hyatt's) genus *Billingsites* with *Mesoceras*, Barr., in the family Mesoceratidæ (Hyatt). Dr. Lindström considers that *Billingsites* should be "placed amongst the Ascoceratidæ near *Glossoceras* on account of its contracted aperture, while *Ophidioceras* may keep

[1] From *χόανος* a funnel.

its more natural place amongst the Lituitidæ, which has been given to it by Barrande."

We desire in closing to express our sincere appreciation of the valuable service the author has rendered to palæontological science in collecting and expounding so many new and interesting facts regarding a hitherto but half-understood genus. We trust he will permit us also to add our congratulations to him upon his admirable handling of our mother-tongue. A. H. F.

The Geology of Mont Blanc.

IV.—"Étude sur les Roches cristallins et éruptives des environs du Mont Blanc." By M. Michel-Lévy. (Bull. serv. Carte géol. France, No. 9, Paris, 1890.)

THE old view of the geological structure of Mont Blanc represented the valley of Chamounix as occupied by a synclinal of Jurassic rocks, nipped in between the schists and gneisses of the anticlinals of the Aiguilles Rouges on the west and of Mont Blanc on the east. This view has been widely circulated owing to the frequent quotation of A. Favre's diagram, in which it is so well expressed. It has not however, during the past few years, been allowed to pass unchallenged. Lory regarded the fact of the schists on the west flank of Mont Blanc dipping eastward, and those to the east dipping westward, as due simply to an ordinary synclinal, and not as a case of the "fan structure." According to this theory, the central "protogine gneiss," which forms the main mass of the mountain, is newer than the schists upon its lower flanks, while the crystalline rocks are faulted up against the Mesozoic beds of the Chamounix valley. Mazzuoli on the other hand regards Mont Blanc as an anticlinal, and the protogine as part of the old "fundamental gneiss," covered to east and west by newer but yet pre-Palæozoic schists. It is clear that in these conflicting hypotheses, the whole question turns upon the nature of the "protogine" and its relations to the surrounding schists. M. Michel-Lévy has therefore subjected this rock to a careful examination, and in the above memoir claims the protogine to be a true granite, intrusive into the schists, and subsequently itself foliated by lateral pressure. This view is supported, first, by a microscopic study of the protogine and its principal varieties, such as the amphibolic protogine, an altered specimen of which was recently described by an English author as an epidiorite. Second, by an examination of the relations of the protogine to the schists, into which it is proved to send numerous veins; the junction of the two rocks is not well shown in the great sections of the valleys of the Glacier d'Argentière and the Mer de Glace, but clear proof of the intrusive nature of the protogine can be seen above Pierre Pointue and round the Aiguille du Plan. Third, by a microscopic study of the "englobements" so numerous near the junction with the schists. M. Lévy rejects Prof. Rosenbusch's view that these are segregations of the first period of consolidation, and argues that they are included fragments of the schists.

If the valley of Chamounix be a synclinal, then there should be some agreement between the sequence of the schists on both sides of the valley. M. Michel-Lévy divides the schists into three zones. The western includes three main types: the granulitic mica-schists (*i.e.* schists injected by granulite) of the Aiguille de Berard, Aiguille côtée, the amphibolites and eclogites of Lac Cornu, and the coarse mica-schists of the Brèvent. The median zone is a series of mica-schists, which extend from the Col du Montet, past the Flégère, and below the Planpraz, along which line they form the slopes at the foot of the crags formed by the coarse schists of the first zone; very similar rocks to these occur at the end of the Glacier des Boissons. The eastern zone is constituted of mica-schists, associated with some amphibolites, and analogous to the rocks of the western zone: this zone can be well studied in the valley of the Mer de Glace, where the schists alternate with interstratified granulites, while both are cut by veins of aplite. Hence though the evidence is inconclusive, the existence of a synclinal is probable. M. Michel-Lévy hopes to obtain more satisfactory proof during the coming season.

The age of the protogine cannot be exactly determined. It is pre-Carboniferous, as fragments of it occur in the Carboniferous conglomerate of Ajoux; it is later than the pre-Cambrian schists (z^2 and probably also x of the French Survey), and so is much younger than the Italian geologists admit.

In addition to the main question discussed in the memoir, valuable contributions are made to the discussion of collateral subjects. Thus the author claims that the microgranulite of La Poya supplies conclusive evidence of the existence of the two different stages of consolidation in granitic rocks. Further that while pre-Carboniferous movements had a great influence on Alpine topography, the extent of later elevations can be seen by the foldings of the Mesozoic beds of the Charollaise and the Maçonnaise. It is also contended that the neighbouring granite of Valorcine has altered true gneiss into the schists in which it is intrusive.

In addition to the woodcuts illustrating the micro-structure of the rocks described, the memoir is accompanied by four admirable photographic views, of which those showing the Mer de Glace opposite the "Angle," and the Aiguille du Chardonnet across the Glacière d'Argentières, are especially pleasing. J. W. G.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 18, 1890.—Dr. A. Geikie, F.R.S., President, in the Chair. —The following communications were read:

1. "The Borrowdale Plumbago, its Mode of Occurrence and Probable Origin." By J. Postlethwaite, Esq., F.G.S.

After giving details of the mode of occurrence of the plumbago of Borrowdale in veins traversing diabase and diorite, which break through the Volcanic Series of Borrowdale, the author refers to the modes of occurrence of plumbago in other regions, and contrasts these with the surroundings of the Lake-District masses. He points out that many thousand feet of volcanic rock supervened between the Borrowdale plumbago-bearing rocks and the overlying carbonaceous shales of Silurian age. On the other hand, he finds similarities between the containing rocks in Borrowdale and the diamond-bearing rocks of South Africa, and considers that the conditions under which the plumbago was formed in the Lake District approached much more closely to those which gave rise to the Kimberley diamonds than to those which originated the plumbago deposits in North America, though there is great dissimilarity in the chemical composition of the intrusive rocks in the two cases, especially with regard to the quantity of magnesia present. He suggests that the molten magma in its upward course passed through a deep-seated stratum of highly carbonaceous material, and tore off numerous fragments, the bituminous matter in which became acted upon by heat, a further alteration being subsequently caused by the intrusion of the diorite.

2. "Notes on the Valley-Gravels about Reading, with especial reference to the Palæolithic Implements found therein." By O. A. Shrubsole, Esq., F.G.S.

The following deposits containing implements are described :—

A. *North of the Thames.*

(i.) Gravel at Toot's Farm, Caversham; 235 feet above sea-level.

(ii.) Clayey gravel by side of Henley Road, Caversham; 168 feet above sea-level.

(iii.) Subangular gravel at Shiplake; 200 feet above sea-level.

B. *South of the Thames.*

(i.) Gravel at Elm Lodge Estate, Reading; 197 feet above sea-level.

(ii.) Gravel on disturbed beds at Redlands; 157 feet.

(iii.) Comminuted flinty gravel at Southern Hill; 223 feet.

(iv.) Gravel at Sonning Hill; 185 feet above sea-level.

(v.) Gravel at Ruscombe, Twyford; 165–170 feet above sea-level.

The author concludes that the highest gravels (235–280 feet above sea-level) do not, so far as is known, contain any traces of Man, and that a considerable amount of valley-erosion occurred before the deposition of the earliest gravels which have furnished human relics. Further, he considers that the deposits indicate the occurrence of a severe climate at an early stage, and its recurrence at a later one, viz. during the deposition of the gravels found at a height of 197 feet and 144 feet respectively above the sea-level. He believes that many of the implements found in the lower levels at Reading have been derived from gravels of various dates and different levels, which have been swept away by denudation, and that this will account for the mixed character of the types of implements.

The next Meeting of the Society will be held on Wednesday, November 12th, 1890.

OBITUARY.

SIR WARINGTON WILKINSON SMYTH, M.A., F.R.S.

For. Sec. Geol. Soc., F.R.G.S.; Lecturer on Mining at the Royal School of Mines, and Inspector of Mineral Property of the Duchy of Cornwall and the Crown.

Born 1817; Died 19th June, 1890.

Sir Warington W. Smyth (whose sudden death from heart disease we recorded in our last Number) was the eldest son of Admiral W. H. Smith, D.C.L., F.R.S., etc., and was born in 1817 at Naples. His mother was the only daughter of Mr. Thomas Warington, British Consul at that city. He was educated at Westminster and Bedford Schools and Trinity College, Cambridge, where he distinguished himself, among other ways, as an oarsman, rowing in the winning University Crew on the Thames in 1839. In this year he took his B.A. degree, and, having gained a travelling bachelorship, commenced a journey which extended over a period of more than four years, and was mainly devoted to a study of the mineral products and mining industries of Germany, Austria, Hungary, European Turkey, and Asia Minor, in the course of which he laid the foundation of that solid and practical knowledge of these subjects which made him throughout his life one of our greatest authorities upon them. On his return to England in 1844, he was appointed by Sir Henry De la Beche to a post on the Geological Survey, and in 1851, on the formation of the Royal School of Mines in Jermyn Street, he became Lecturer on Mineralogy, and on Mining, retaining the former chair till 1881, and the latter to his death. About the same time he was appointed Inspector of the Mineral Property of the Duchy of Cornwall, and soon afterwards Chief Mineral Inspector to the Crown, under the Commissioners of Woods, Forests, and Land Revenues. For the Geological Society he has done good service, having been one of the Honorary Secretaries from 1856 to 1866, President in 1866 and 1867, and Foreign Secretary for the last 16 years. In 1879 he was appointed Chairman of the Royal Commission on Accidents in Coal Mines, to the duties of which office he devoted much labour, in addition to the performance of his ordinary professional work during the seven years in which the Commission was sitting. For this and other public services he received the honour of knighthood in 1887. Besides various technical reports and contributions to purely scientific literature, he published in 1856 a book entitled "A Year with the Turks," and in 1867 "A Rudimentary Treatise on Coal and Coal Mining," a standard work now in its sixth edition, which has been translated into the principal European and also the Chinese languages. Although he was not a man who cared much to place himself before the world, he commanded the respect and esteem of all who came into contact with him in no common degree, and it will be difficult to replace him in the particular branches of Science which he had made especially his own. He may be said almost to have died in harness; for, notwithstanding that he had been for some months out of health to such an extent as to cause anxiety in the minds of his intimate friends, he could scarcely be persuaded to give himself any relaxation from his official labours, the scrupulously conscientious performance of which had characterized him throughout life, and he attended the *soirée* of the Royal Society on June 18th, the evening before his death. Sir Warington Smyth married, in 1864, Antonia, daughter of the late A. M. Story-Maskelyne, of Basset Down, Wilts, and he leaves two sons.

As a lecturer on Mining to students he was most popular, and his discourses were amongst the most largely attended of any of those delivered at the Royal School of Mines. These lectures were never published, but a short-hand report of the course, taken by a writer employed by Prof. John Milne, F.R.S., of Tokio, Japan, when he was himself one of Prof. Smyth's students, and afterwards privately printed, exists in the archives at Jermyn Street. It would be a pleasing memorial to Sir Warington Smyth, if some of his old students undertook to reprint these (after being carefully edited), and issued them as a testimonial of their love and esteem for their Professor.

ROBERT WILLIAM MYLNE, F.R.S., F.G.S.

Born, June 14, 1816; Died, July 2, 1890.

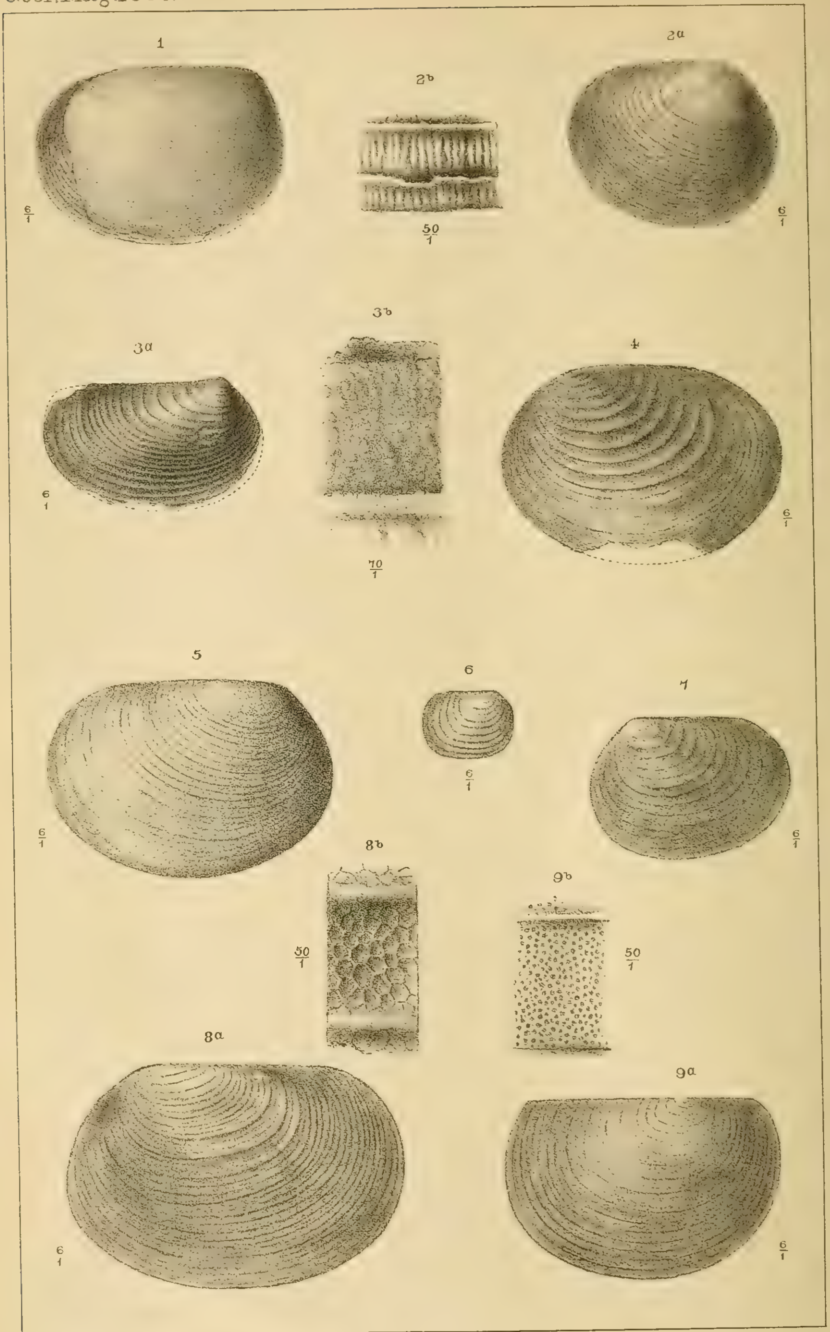
We regret to record the death of another old member and past officer of the Geological Society of London. Mr. R. W. Mylne, F.R.S., who died on the 2nd July, 1890, in his 75th year.

By profession Mr. Mylne was a Civil Engineer and Architect, particularly directing his attention to matters concerning the Water-supply of large towns. This special bias to his career was doubtless greatly due to the fact that his father held the post for fifty years of Engineer to the New River Company. Although not himself an official of that Company, he took part in engineering work required by them, in association with his father, for about twenty years. The knowledge so obtained is shown in his evidence before the Royal Commission on Water-Supply on the 6th June, 1867, and in his paper "On the Supply of Water from Artesian Wells in the London Basin, with an account of the Sinking of the Well at the Reservoir of the New River Company at Hampstead Road;"[1] and in his work published in 1850, "Sections of the London Strata," in which many "deep wells" of those days are recorded, but none of them pass through the Chalk; the deepest being 522 feet.

About 1857 he published a Contour Map of the Metropolis, and in 1871 a similar map, geologically coloured, appeared. He was elected a Fellow of the Geological Society of London in 1848; and was on the Council of that Society from 1854 to 1868, and again in 1879. In the years 1856 and 1857 he held office as one of the Secretaries, the other being the late Sir Warington W. Smyth, F.R.S. He was elected a Fellow of the Royal Society in 1860. For many years he served the office of Treasurer to the Geological Club.

W. R. J.

[1] Trans. Inst. Civil Eng. vol. iii. pp. 234–244, 1842. This includes Reports by W. C. Mylne and J. Simpson.



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FOSSIL ESTHERIÆ.

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

No. IX.—SEPTEMBER, 1890.

ORIGINAL ARTICLES.

I.—On some Fossil Estheriæ.

By Prof. T. Rupert Jones, F.R.S., F.G.S., etc.

(PLATE XII.)

A. *Triassic Estheriæ.*
- I. North-American Fossil Estheriæ.
  - 1. *Estheria Lewisii*, sp. nov.
  - 2. *Other North-American Estheriæ.*
- II. *E. minuta* (Alberti) and *laxitexta*, Sandberger, from Bavaria.

B. *Purbeck Estheriæ.*
  - 1. *E. subquadrata* (Sow.)
  - 2. *E.* sp. undescribed.

A. Triassic Estheriæ.

I. *North-American Estheriæ.*

1. Estheria Lewisii, sp. nov. Pl. XII. Figs. 3*a*, 3*b*.

THIS species is represented by one cast and part of another, in red sandstone from Bucks Co., Pennsylvania, given to me not long before his death by my lamented friend, Professor Henry Carvill Lewis, F.G.S., etc., of Philadelphia.

Length 5 mm. Height 3 mm.

Valve narrow-subovate or oval-oblong; straight above (hinge-line to length of valve nearly as 23 to 30), neatly curved below, though the edge is not quite perfect; rounded at the extremities; umbo strong, a sixth of the valve's length from the front end. The concentric ridges of the surface, 19 or 20, strong and wide apart in the early part of the valve, closer but very distinct afterwards. The casts seem to show traces of interstitial markings in irregular vertical lines (Fig. 3*b*); but unfortunately these are partly due to the sand-grains of the matrix and the partial coating and staining of iron-oxide.

As this form differs from any other known, I propose to regard it as a new species, *Estheria Lewisii*, dedicated to the memory of one of the most promising and most regretted of geologists. His short life and brilliant works are recorded in the Geol. Mag. for September, 1888.

A brief account of the geology of Bucks County, Penna, whence Prof. H. C. Lewis received the specimens of *Estheria Lewisii* here described, is given by Prof. J. P. Lesley in the "Geological Hand Atlas of the Sixty-seven Counties of Pennsylvania," etc , in the

"Second Geological Survey of Pennsylvania: Report of Progress, X." 1885. At pages xxviii and xxix it is stated that "most of its surface is a gently rolling, highly cultivated country of Mesozoic New-Red sandstone and shale, all dipping north-westward at angles varying from 5° to 15°, for 33 miles (in a straight line) along the river [Delaware] . . . . . . The Mesozoic formation is of the same character throughout,—an alternation of hard and soft layers of reddish sand and mud, some fit for building-purposes, some conglomeratic, a few calcareous, and some (near the middle of the formation) fossiliferous, containing numerous bones of large sea-lizards, shells, and plants."

2. Other North-American Estheriæ.

The best of Prof. Lewis's specimens (Fig. 3*a*) is unlike any of those from North America figured in pl. 2 of the "Monogr. Foss. Estheriæ, Pal. Soc." 1862. Among the woodcuts of these Estheriæ, copied at pp. 86-7 of the "Monograph," fig. 6 (*Estheria ovata*, Lea, sp.; *Posidonia multicostata*, Emmons) is the nearest in shape, but differs in the number of concentric riblets. Fig. 8 (*E. ovata*, Lea, sp.; *P. ovalis*, Emmons) has the concentric lines more similar, but the outline is very different. My statement, that these and the other woodcuts are of little or no use towards the discrimination of species, unfortunately still holds good. I suggested at p. 91, that fig. 28 of pl. 2 may be the same as figs. 26 and 27, the shape being the same; the first-mentioned, however (figs. 28–30), has not only very close-set concentric lines of growth, but *smooth* interspaces; and fig. 31 shows the same feature, sufficient to characterize a species. Unfortunately we have no certainty about the interstitial ornament of the wide-ribbed figs. 26, 27. Nor can we refer the reticulate ornaments, figs. 32, 34, 35, 36, so much like that of the European *E. minuta*, and fig. 33, corresponding with that of *E. Brodieana*, to any known form from Pennsylvania, Virginia, or North Carolina. Much less the ornaments shown by figs. 37 and 38 of pl. 2. These isolated pieces of ornament were taken from parts and pieces of badly-preserved North-American *Estheriæ*, and probably indicate five or six different species. Figs. 26 and 27 may very well represent one of these species, most likely one with *reticulate* interspaces; but there is as yet no proof of this relationship.

The following Table shows the leading characters of the North-American fossil *Estheriæ* figured in pl. 2 of the "Monogr. Foss. Esth. Pal. Soc." 1862:—

Fig. 26, 27. From Prince Edward, near Richmond, Virginia ...	Concentric lines wide apart.
,, 28. Harding's pit, near Richmond	Concentric lines numerous and close together.
,, 29 and 30. The same	Smooth interspaces.
,, 31. Richmond	The same.
,, 32. Richmond	Reticulate interspaces, like those in *E. minuta*; probably somewhat squeezed cross-wise.
,, 33. Richmond	Small reticulation, like that in *E. minuta*, var. *Brodieana*.

Fig. 34.	Dan River	Reticulation, like that of fig. 32, and probably slightly squeezed in the same way.
,, 35.	Dan River	Similar reticulation, but squeezed obliquely.
,, 36.	Richmond	Similar reticulation, either squeezed sideways, or naturally crossed with slight vertical ridges.
,, 37.	Dan River	Columnar interstitial ornament, like that in some Wealden specimens, and in the recent *E. similis*.
,, 38.	Richmond	Interspaces filled with coarse parallel thread-like lines, one separated from another by a row of small pits.

Figs. 26 and 27 are good examples of subovate valves, with open concentric ribbing, but have lost all trace of their interstitial ornament; fig. 28, though of the same shape, differs from the foregoing in the closeness of its lines of growth.

The ornamentation shows that figs. 32, 34, and 35 are decidedly of one species; fig. 33 may be a variety of the same; fig. 36 is either the foregoing large reticulation squeezed sideways, or that of a different species; fig. 37 and fig. 38 are also distinct species.

We have no better grounds for taking these characters of imperfect specimens as the basis for *naming* the possible species than we had in 1862, when I grouped them all under Lea's name "*ovata*," on account of the possibility of bad drawings of badly preserved specimens making differences where none really exist.

Prof. J. D. Dana, in his "Manual of Geology," 3rd edit. 1880, p. 410, gives in fig. 711 a drawing like fig. 5 (Lyell's woodcut), p. 86, Monogr. Foss. Esth., for *E. ovata* (Lea); in fig. 711*a*, *E. ovalis* (Emmons), like the fig. 8, p. 87, *op. cit.*; and in fig. 711*b*, a small, neat, suboval valve (apparently the same as "*Estheria ovata*," fig. 261, p. 169, "Text-book of Geology," 1870) as *E. parva* (Lea). This is an acceptable plan, if "*E. ovata*" can be allowed (as in 1862) to cover the group, although Emmons's *multicostata* was said by Conrad to be the same as Lea's *ovata*; the latter to be apparently not the same as Lyell's specimens (fig. 5, p. 86, Monograph, & pl. 2, fig. 28); and Emmons's *triangularis* (p. 86, fig. 7) to be probably the same as Lea's *parva*. We still want perfect drawings or good examples of these forms. Prof. H. Carvill Lewis hoped to get some for examination; but the specimens now before us are all that opportunity permitted him to obtain before he was taken from us.

II. *Estheria minuta* (Alberti), and *E. laxitexta*, Sandberger, from Bavaria, etc.

Some years ago my friend Dr. Fridolin von Sandberger favoured me with several specimens of *Estheria minuta* (Alberti) and *E. laxitexta*, Sandberger, but it has been only of late that I could take them in hand for careful examination. The following have been selected as specimens showing good shapes of *E. minuta*.

Figs. 4, 5, and 6 are in a grey, micaceous shale, with ferruginous impressions of plant-remains, from the Lettenkohle, at Fulda, Hessen-Cassel.

Fig. 4 corresponds closely with fig. 4, pl. 2, "Monogr. Foss. Estheriæ," 1862, but has rather weaker umbo and stronger concentric wrinkles; Fig. 5 is like fig. 29, pl. 1, but is weak in the umbo (like Fig. 4), and has more numerous and less pronounced concentric wrinkles; in its straight back and feeble lines of growth it is like fig. 5, pl. 2, but its postero-ventral curve is much fuller. The little Fig. 6 matches fig. 14, pl. 2, the small Rhætic variety *Brodieana*, but it has not quite so prominent an umbo, and is rather squarer in outline.

Fig. 7, labelled "*E. Albertii* (Voltz), Baden," is in a hard micaceous shale, light-grey and purplish; it is not much larger than fig. 9, pl. 2, and differs only triflingly in outline, being rather fuller in the antero-ventral curve, less angular in front of the umbo. and having slightly stronger concentric ridges. With its relatively small size and oblong shape Fig. 7 ($4\frac{1}{2}$ by 3 mm.) comes in as a large form of var. *Brodieana.* It is from the upper red clay of the Grès bigarré, at Durlach, Baden.

In a piece of thin, dull-red shale from the Pfinzthal, Baden, is a shining, compressed cast of another specimen, labelled "*E. Albertii* (Voltz)," similar to Fig. 7, and measures 4 by 3 mm.

On one of the bed-planes of an inch-thick mudstone, dark-grey, hard, fine-grained, and slightly micaceous, from the Lettenkohle of Würzburg, Bavaria, are numbers of a small form of "*Estheria minuta*" (about 4 by $2\frac{1}{2}$ mm.) crowded together. On the other bed-plane is a group of *Pullastra*-like bivalves in casts and impressions.

Fig. 8, labelled "*E. laxitexta*, Sandberger, from the Estheria-bed of the Lower Keuper, at Windsheim, Middle Franconia," is a fine large *Estheria* with shape and ornament like those of *E. minuta*, Fig. 8*a* is comparable with fig. 5, pl. 2, of the "Monogr. Foss. Esth." 1863, though somewhat larger, and having a fuller curve at the antero-ventral margin. The reticulate sculpture of the concentric interspaces is essentially the same as that in figs. 3 & 7 of the pl. 2 referred to, so that I cannot find good ground for following Prof. Dr. Fr. von Sandberger in separating this form from *E. minuta.* He tells me in a letter (May 8th, 1890), that he "separated *E. laxitexta*, which occurs high above the stratum with *E. minuta*, from that species on account of the difference in the sculpture; that he has not described nor figured it; and that its relatively larger size was not the reason of his separating it from *E. minuta.*" Certainly the slight difference in size and contour is not sufficient for a specific distinction; and the sculpture of the selected specimen shows no difference.

E. laxitexta was mentioned by Dr. von Sandberger in the "Verhandlungen d. k. k. geol. Reichsantalt" (Wien), No. 16, 1871, p. 323, in a note on the Estheria-bed of the Keuper in South France; but, by some mistake, it is there stated to have been described, from English specimens, by me, as a variety of *E. minuta*, occurring exclusively in the Lettenkohle.

Some of the specimens before me are numerous and relatively well preserved on the bed-planes of a greenish shale, rather hard and slightly micaceous, from near Bayreuth (Upper Franconia) and in the Steigerwald, like (von Sandberger states) the Estheria-bed of the Keuper in Swabia and in the Department Gard in South France. Others lie less regularly in a grey, harder, and more solid mudstone or shale, slightly micaceous, from the Lower Keuper of Windsheim, Middle Franconia (Bavaria).

B. Purbeck Estheriæ.

1. Estheria subquadrata (Sowerby). Pl. XII. Figs. 1, 2*a*, 2*b*.

Estheria elliptica, Dunker, var. *subquadrata* (Sow.), Monogr. Fossil Estheriæ, Palæont. Soc. 1863, pp. 103–109, pl. 3, figs. 18–29.

	Length.	Height.
Fig. 1.	5·6 mm.	4·0 mm.
Fig. 2.	4·5 mm.	3·8 mm.

Doubtless there is a close zoological connection between *Estheria elliptica*, Dunker, and *E. subquadrata* (Sow.), but it now appears to me, especially as no specimens exactly like Dunker's type ("Monogr. Foss. Esth." pl. 4, fig. 1), nor its most quadrate variety (fig. 3), have been met with in England, that it will be advantageous to palæontologists for us to allow the slight difference in outline, and the more striking difference in the interstitial ornamentation, to constitute specific (and not merely varietal) distinctions, and thus allow *E. subquadrata* to stand by itself as a species.

The specimens collected by the Rev. W. R. Andrews, F.G.S., in the Vale of Wardour, and kindly submitted by him for examination five or six years ago, comprise an internal cast retaining only a small remnant of the test, Pl. XII. Fig. 1, and a perfect, but smaller, individual, Fig. 2*a, b*. In Fig. 1 we have an oblong form, with advanced anterior angle, and a nearly vertical, slightly convex front edge. This is proportionately shorter than fig. 23 in pl. 3, "Monogr. Foss. Esth.," and more fully curved on the ventral margin; but its long back distinctly separates it from fig. 3 of pl. 4 *op. cit.*

In our Fig. 2*a* we see the nearly exact counterpart of fig. 19, pl. 3, of the Monograph, with an ornament corresponding more or less closely with that of figs. 21, 22, 24, 28, and 29 (from the Wealden of Sussex), but not with that of the Hanoverian specimens (pl. 4, figs. 4, 5, and 7).

These specimens (Figs. 1 and 2, sent to me about 1884) occur in a brownish sandy (Middle-Purbeck) stone, a little above the top "lias" of the Purbeck beds, in the limestone-quarry, at Teffont-Ewyas; and the same form is abundant in specimens (sent in November, 1888) of a Cypridiferous limestone on the same horizon, a little below the "Cinder," and therefore also from the Middle Purbecks. In the sandy bed fragmentary twigs of a *Thuia* occur; and in the limestone *Cypridea punctata* is plentiful, with *Cyprione* (probably *C. Bristowii* and another), and *Metacypris* (?). This Estherian limestone was from a small quarry on the railway south of the River Nadder, at Lower Chicksgrove, about two miles west of the Rectory where the Rev. W. R. Andrews resides.

2. Lately Mr. Andrews has discovered some other *Estheriæ*, larger in size, and with a different ornamentation, and therefore of a distinct species, in a band of black and brown shaly clay, with the Middle-Purbeck *Cypridea fasciculata*, five feet below the horizon of the *Estheria subquadrata* mentioned above, and in the same quarry as that in which the specimens shown by Figs. 1 and 2 were found.

EXPLANATION OF PLATE XII.

Fig. 1. *Estheria subquadrata* (Sow.). Internal cast of a right valve; not quite perfect; × 6 diam.

,, 2. ——— *a*, Right valve of the young form or variety; × 6 diam. *b*, Interstitial ornament; × 50 diam. Figs. 1 and 2 from the Vale of Wardour.

,, 3. *Estheria Lewisii*, sp. nov. *a*, Internal cast of a right valve, rather compressed; × 6 diam. *b*, Imperfect traces of interstitial ornament; × 70 diam. From Pennsylvania.

,, 4. *Estheria minuta* (Alb.). Left valve; × 6 diam.

,, 5. ——— Right valve of an individual with numerous lines of growth; × 6 diam.

,, 6. ——— Right valve of the small variety *Brodieana*; × 6 diam. Figs. 4, 5, and 6, from the Trias at Fulda, Hessen-Cassel.

,, 7. ——— Left valve of a small or young individual; × 6 diam. From the Trias of Baden.

,, 8. ——— (*E. laxitexta*, Sandb.). *a*, Left valve of individual with numerous lines of growth; × 6 diam. *b*, Interstitial ornament of another specimen; × 50 diam. From the Trias of Bavaria.

,, 9. *Estheria membranacea* (Pacht). *a*, Right valve of an individual of the long variety; × 6 diam. *b*, Interstitial ornament (unusually well preserved); × 50 diam. From the Old Red of Orkney.

II.—Vertebrate Palæontology in some American and Canadian Museums.

By A. Smith Woodward, F.G.S., F.Z.S.,

of the British Museum (Natural History).

IN the Palæontology of the Vertebrata, so much has been accomplished on the American Continent within recent years, that any European interested in this line of research is naturally attracted to the Museums and collections across the Atlantic. Among others, the writer of the present notes has at various times been desirous of comparing certain American and Canadian discoveries with those now familiar to workers in the Old World; and this desire having lately been gratified, it may not be uninteresting to offer a few remarks on the collections of extinct Vertebrata in the New World, viewed from the standpoint of one who has had the privilege of visiting many of the corresponding collections in Europe.

New York.

The Geological Museum of the Columbia College, New York, due to the labours of the present Professor, Dr. J. S. Newberry, comprises the finest collection of American Palæozoic Fishes hitherto brought together. The Museum occupies the upper storey of the new School of Mines, and is thus well lighted from above; while the cases are small and conveniently arranged for study. The lecture room immediately adjoins, and the only inconvenience is the close proximity of the railroad—a much more noisy neighbour than its English counterpart. The large majority of American Palæozoic Fish-remains (except Selachian teeth) having been made known in the works of Dr. Newberry, the collection is especially rich in type-specimens; and the fine case of *Dinichthys* with its allies, well mounted for exhibition, is a display such as none of the well-known Scottish series of Placoderm fishes can equal. The collection is still being rapidly augmented, and all the more important of the latest acquisitions are described in Dr. Newberry's new volume just issued by the U. S. Geological Survey.

The bones of *Dinichthys* and its allied genera usually occur in a black shaly matrix, from which they can be completely extricated; and they are often associated in natural groups, the plates of a single individual being met with together, though difficult to disinter intact on account of their huge dimensions. To one accustomed to the skeleton of the common *Coccosteus*, the remains of the American fish appear as magnified representatives of familiar bones; and other equally gigantic modifications of the same type have lately been named *Trachosteus* and *Titanichthys*.

Next to the Placoderm Fishes, the most striking of recent acquisitions are nearly complete examples of one of the Carboniferous sharks whose teeth have long been known under the name of *Cladodus*. Though showing some remarkable features,—such as a ring of circumorbital plates, abbreviate pectoral fins, and a diphycercal tail with a pair of great horizontal expansions of integument at its base,—the fish invariably rests upon its back (having been round-bodied), and thus gives no clue to one interesting character, *i.e.* the presence or absence of dorsal fin-spines. Among other unique types is the Devonian *Onychodus*, with the strange coil of spike-like teeth undoubtedly fixed in front of its lower jaw; and all the bones of this fish are so remarkably scattered that it is still difficult to form any conclusion as to its affinities. Numerous jaws of Devonian Chimæroids, the spines of *Machæracanthus*, and various remains of small Placoderms are also almost unique; and among the Carboniferous Limestone fossils are numerous types of Selachian spines and teeth. Of the latter, the great teeth named *Archæobatis* are perhaps most conspicuous; and these, it will be observed, differ in no respects from the British teeth assigned to *Psammodus*, except in the coarser nature of their coronal ornament. A large series of Cœlacanth, Palæoniscid, and other fishes, with several Amphibia, from the Coal-measures of Ohio, forms the type collection described by Profs. Newberry and Cope in the Reports of the Geological Survey of Ohio. Still higher in the geological scale, another fine collection of fishes illustrates the American Trias; and this, again, has been made available for reference by the Professor's well-illustrated volume published by the U. S. Geol. Survey in 1888. Many of these specimens were obtained from an excavation specially made at Boonton, New Jersey, which not only enriched the Museum with material, but added greatly to previous knowledge of the fish-fauna in question.

The American Museum of Natural History, in the Central Park, though as yet insignificant when compared with the plan for its completion, already comprises fine, lofty exhibition galleries and work-rooms, and, in addition, is provided with the largest and most completely fitted lecture theatre that has hitherto been built in conjunction with an institution of this kind. Each spring and autumn, the theatre is occupied by Prof. Bickmore, who delivers a series of free lectures, illustrated by the lantern, to the Teachers of the Public and Normal Schools in the State of New York. The lantern slides are largely prepared by the Museum, and the syllabus comprises not only pure Natural History, but also subjects in Geography. General public instruction is also one of the main objects in all the exhibition galleries, and the collection is displayed accordingly. In the Geological Department, for example, under the charge of Prof. R. P. Whitfield, a series of table-cases is exclusively devoted to the illustration of Dana's well-known Manual, of which a copy is kept for the use of visitors. At the same time, the Naturalist is not forgotten, and there is probably no Museum of equally recent foundation that possesses a more representative collection or more valuable type-specimens. Among Vertebrates, the Mastodon and Irish Deer form conspicuous centre-stands; but the other remains are comparatively small and scattered through the collection, which is arranged stratigraphically as a whole, with zoological divisions in each of the various stages. The principal series of types was obtained from the James Hall Collection, which comprises many Mammalian remains from the Tertiary Formations of the West, and numerous examples of American Devonian Fishes. The former are described in Prof. Leidy's "Extinct Mammalian Fauna of Dakota and Nebraska"; while the latter have been studied by Prof. Newberry, and employed in various publications. The type specimen of *Sauripteris* made known by Prof. Hall, from the Catskill Group, is one of the most conspicuous of the ichthyolites, and doubtless pertains to the family recognized in Britain under the name of Rhizodontidæ; while another unique fossil is a cranial shield of the Placoderm *Asterosteus*, showing the laterally placed orbits, large narial openings, and a pineal foramen.

Princeton.

The collection of extinct Mammalia in the University of Princeton, New Jersey, has become well known through the researches of Professors Scott and Osborn, and is beautifully mounted and labelled in the E. M. Museum ("E. M." being the initials of a benefactress). The larger and more prominent specimens are placed on a central platform; while the smaller and more delicate objects are arranged in an adjoining series of wall-cases. Conspicuous among the large specimens, is the complete skeleton of a remarkable Deer, from the Pleistocene of New Jersey, intermediate between the true *Cervus* and *Alces*, and described by Prof. Scott under the name of *Cervalces Americanus*. Accompanying this are two fine skulls and the greater portion of the fore- and hind-limbs of *Uintatherium*, from the Bridger Eocene of Wyoming; the shell of a large Tortoise (*Hadrianus Corsoni*) also from the Bridger Eocene of Wyoming; and an American Mastodon, besides a French Cave Bear and an Irish Deer. An unique skeleton of the Creodont *Mesonyx*, described by Prof. Scott, is shortly to be mounted and added to the exhibition series from the Bridger Eocene, which is especially well represented in all groups. A goodly number of the well-known fishes of the Green River Shales is also exhibited; and the collection of typical European fossils (chiefly due to Prof. Henry A. Ward, of Rochester) is especially complete, affording valuable material for comparison. The Professors at the present time are extending their researches to the fossil Mammalian collection of the Agassiz Museum, Cambridge, placed at their disposal by Prof. Alexander Agassiz; and portions of the results of their researches have already appeared in the Cambridge Bulletins.

Philadelphia.

Two centres of attraction to the Vertebrate Palæontologist exist in Philadelphia—the Museum of the Academy of Sciences, and the private collection of Prof. E. D. Cope. Neither of these collections is at present displayed to good advantage, but there is a prospect shortly of both being accommodated with convenient rooms and cases. The foundations of the new Museum at the Academy are already laid; and the Pennsylvanian University is preparing adequate accommodation for the collection of Prof. Cope, who has lately been appointed to its Chair of Geology.

The gem of the Academy Collection is the original specimen of *Dromatherium sylvestre*—a mandibular ramus in black coaly matrix from the Trias of Chatham Co., N.C. Its parts are as distinctly shown as in any of the Mesozoic mammalian jaws from England. Another unique specimen is the head of the Cretaceous Crocodile of New Jersey, *Thoracosaurus neocæsariensis.* This is also well preserved and shows most distinctly the true antorbital vacuities (described by Prof. Leidy), which some would erroneously explain as mere fractures. The Cretaceous Dinosaur, *Hadrosaurus*, is represented by the fine series of bones upon which Prof. Leidy originally founded the genus; but these are not shown to advantage in Waterhouse Hawkins' plaster restoration, which still survives, with the exception of the pelvis. The earliest series of fish-remains from the American Devonian and Carboniferous, described by Prof. Leidy, occupies part of one of the wall-cases, and comprises many interesting fragments; while most of the teeth and scales from the Cretaceous of New Jersey and the Phosphate Beds of South Carolina, made known in the same Professor's well-known memoirs, are arranged on adjoining shelves. A very large number of Tertiary Mammalian remains, including, among others, the type-specimens of *Megalonyx*, are placed in other cases; and Prof. Leidy is at present resuming the early researches to which these specimens bear witness, by investigating a large collection of Mammalian bones lately brought by Mr. Joseph Willcox from Florida. The collection of British Fossils is extensive and affords useful material for comparison, having been acquired by the Academy from Dr. T. B. Wilson. There are many interesting Old Red Sandstone fishes from Cromarty bearing Hugh Miller's autograph labels; several Wealden bones labelled by Dr. Mantell; a good representation of the English Lias; and a few examples of the Bristol Dolomitic Conglomerate with the remarkable Triassic reptilian bones.

The greater portion of Prof. Cope's collection at present occupies the rooms of a private house, while many of the larger specimens are stowed away in the basement of one of the public museums. The lower room is the only one in which there is any attempt at display, such as would interest an ordinary visitor; but the apartments are fitted with shelves and drawers, where nearly all the specimens are placed in small boxes for convenient reference. When it is remembered that the large majority of the type-specimens described by the Professor are comprised in the collection, its richness will at once be understood; and the fossils are accompanied by a large number of recent zoological preparations, notably the Hyrtl Collection of fish-skeletons. In the exhibited series, the well-known skeleton of *Phenacodus*, the skulls of primitive Rhinoceroses, Camels, and other Mammalian bones are conspicuous; while the huge vertebræ and limbs of *Camarasaurus*, some Mosasaurian remains, etc., represent the Reptilia. The collection of Permian Amphibia, Reptilia, and Pisces from Texas, is unique; and the remarkable preservation of the skeletons in the red sandy matrix enables all the varied anatomical points made known by Prof. Cope to be clearly observed. The writer was especially interested in the skulls of the Ichthyotomous Elasmobranch "*Didymodus*," which certainly exhibit with distinctness the extraordinary fissuring of the chondro-cranium as described; though, in the strict sense of the term, is it scarcely accurate to name the segmented parts "bones"? *Ptyonodus* is also worthy of note as being founded upon teeth identical with those lately named *Hemictenodus* in Britain. The American Cretaceous collection is especially rich in Reptilia and Pisces, both from the adjoining State of New Jersey, and from the distant territories of the West. One small series of fossil fishes, from the Niobrara Beds of Dakota (described in Bull. U.S. Geol. Surv., vol. iv. No. 1), is contained in matrix identical in every respect with that of Sahel Alma, Mount Lebanon, and is of especial interest as comprising the same group of generic types as is now well known from the Asiatic locality. The Chimæroid teeth from the Greensand of New Jersey are also conspicuous, and would, in Britain, be nearly all referred to the genus *Edaphodon*. The North American collection is supplemented by a large series of (supposed) Cretaceous fish- and crocodilian-remains from Brazil, chiefly discovered by Mr. Joseph Mawson, F.G.S.; and among these may be noted a representative of the European and Asiatic Upper Cretaceous genus *Palæobalistum* (*Pycnodus flabellatus*, Cope), besides the well-preserved *Anædopogon tenuidens* from Ceara, which is identical with the fish bearing Agassiz' MS. name of *Cladocyclus Gardneri*. Among earlier Palæozoic fishes, the fine type-specimen of *Macropetalichthys* is also here, and much new information as to the characters of this remarkable shield will shortly be published by Professor Cope, who has lately been occupied in the study of the primitive group to which it is referred. Still more interesting, perhaps, is the type of the Carboniferous shielded organism, named *Mycterops*, which the Professor has naturally regarded as most difficult of interpretation, if truly one of the Chordata, as he originally supposed. The present writer's somewhat extensive examination of Pteraspidian and other early Chordate types in Britain, Sweden, Russia, and Germany, has led him to the conclusion that *Mycterops* is certainly not related to any of these forms, but is truly an Eurypterid, with which the texture and superficial aspect of the specimen agree precisely. This determination, it may be added, is also adopted by Dr. R. H. Traquair, who informs the writer that he had already suspected some such affinity from a study of the published figure and description. Space prevents any adequate notice of the superb series of Tertiary Mammalian remains, of which the figures are now familiar to most palæontologists; and it is to be hoped that ere long these will be provided with the suitable mountings and cases that their delicate state of preservation demands.

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

III.—Note on the Denudation and Elevation of the Weald.

By Horace W. Monckton, F.G.S.,
of the Inner Temple.

It is, I think, practically admitted that the present condition of the Weald is the result, firstly of marine, and secondly of subaerial denudation. A plain of marine denudation was first formed, and the valleys were carved out by subaerial action.

As the Weald at present exists, we find the lower beds swelling up in the centre of the area from beneath the newer ones which lie around, and we also find that certain of these older beds are thickest in the centre, and gradually thin out towards the north, and probably also towards the south. The older beds in the centre are thus at a higher level above the sea than the newer ones around them. It has been suggested (Topley, Q.J.G.S. vol. xxx. p. 186) that the height of the lower beds in the centre may be due to the manner in which they were deposited, rather than to an excess of upheaval in the centre of the area; but this can scarcely be so, I think: for it seems hard to imagine a series of successive beds deposited most thickly one after another on the same spot, thus forming a high mound—the tendency of deposition being to fill up hollows, not to increase the height of hills.

If, however, we assume that the excess of deposition was the result of and coincided with an excess of depression, the matter becomes simple. Thus, from some undetermined period until the formation of the Gault, the south-east of England was an area of depression, and the progress of depression was more rapid upon the east and west line which now forms the anticlinal of the Weald than either to the north or to the south of it. If my readers will turn to Mr. Topley's diagrammatic section, plate vi. p. 242 of his memoir on the Weald, they will see that depression was more rapid under Crowborough Beacon than under London; and as deposition always attempts to fill up hollows, the rate of deposition was higher and the beds thicker in the former than in the latter locality. This was clearly the case during the period from the beginning of the Purbeck to the end of the Lower Greensand.

Since that time a change in the earth movement of this area has taken place; for the line, which was then a line of excess of depression, has since become a line of excess of elevation forming the great anticlinal of the Weald; and it is clear that when the excess of depression on this line ceased, deposition would tend to become more uniform over the whole area; and when the line began to rise, deposition would be less over it than over the adjoining areas which were stationary or rising more slowly.

The great regularity in the thickness of the Gault on the north and south of the Weald leads me to suspect that the excess of depression of the central area ceased during the Gault period; and it is quite possible that if that area was beginning to rise during the Chalk and Tertiary periods, little or no Chalk or Tertiary beds were ever deposited there; and I look with suspicion on any estimate of the original height of the Wealden anticlinal founded on the assumed regularity of deposition over the whole area.

I thus reach the period when the elevation of the south-east of England began, and proceeded at a rate varying greatly in different places, thus forming the anticlinal of the Weald. At this point I am in conflict with the views of previous writers as to the formation of a plain of marine denudation. As I understand them, they contend that the plain was formed by the *advance* of the sea across the area "so as to shave it across." I doubt this. I believe the plain was formed during the *retreat* of the sea, that is to say, during the struggle of the land and water for mastery.

If I am right, the central portion of the area which was being elevated the more rapidly first reached the surface of the sea, and on reaching the surface was at once destroyed by the waves; but as time went on, and the area of elevation gradually extended, a larger and larger surface of the sea-bottom was brought in conflict with the waves, and it is not hard to picture to oneself the progress of the conflict and the final victory of the earth over the water. When the Wealden area, therefore, first rose above the sea, it presented, according to my theory, an extensive sandy flat; and as it emerged, subaerial denudation set in, which has gradually produced the present surface of the country.

In a well-known text-book the general effect of a partial submergence of the Weald is represented by a straight line parallel to sea-level; but, if I am correct, this is probably inaccurate: for if the area rises and falls at a rate varying in different parts, the effect of submergence would be represented by a curved line.

It is quite true that large areas may be elevated or depressed without losing their horizontality. According to Sir C. Lyell, the primary rocks remain horizontal over thousands of square leagues in America and Russia, in spite of great oscillations of level (Antiq. of Man, 1873, p. 396). But any given area must be judged by the evidence applicable to itself, and there is plenty of evidence that the South of England has been subject to differential earth movements at various times. Thus the Chalk of the Hog's Back and Culver Cliffs was placed at its present angle by differential elevation during post-Bagshot times. The occurrence of Crag at Lenham seems to show that that portion of the country was submerged when the west was dry land. According to Prof. Prestwich, the old beach which is 8 to 12 feet above the sea at Brighton rises to 100 feet near Arundel, to 130 feet near Chichester, and to 140 feet at Bourne Common, and then falls to 125 feet above the sea at Portsdown Hill (Q.J.G.S. vol. xxviii. p. 38, Topley, Weald, p. 286); and if this is so, we have not only evidence of differential elevation, but of elevation in a curve instead of a straight line.

My conclusions are :—

1.—That during the deposition of the Wealden and Neocomian beds in the south-east of England, the area was one of depression, that the rate of depression of the centre was in excess of that of the surrounding area, thus causing the thickening of the beds towards the centre.

2.—That upon the area becoming one of elevation, the elevation was most rapid in the centre.

3.—That a large portion of the beds were removed by marine denudation as they rose out of the sea, a large sandy plain thus being formed; and that the plain of marine denudation spoken of by authors was not due to the advance of the sea over land.

Note.—Since this was written Prof. Prestwich's papers on the Westleton Beds have been published. He appears to attribute more of the denudation of the Wealden area to subaerial agencies than former authors.—H. W. M.

IV.—Tertiary and Post-tertiary Stratigraphy.

By Thos. R. Struthers.

Hon. Assoc. and late Vice-President, Geological Society of Glasgow.

As a basis for the following observations on the classification of Tertiary and Post-tertiary strata, we submit a comparative view of the nomenclature adopted by various authors.

	Lyell.	Dr. Hull.	Prof. Geikie.	J. B. Jukes.	Prof. Prestwich.
Post-tertiary.	1 Recent 2 Post-pliocene	1 Recent 2 Post-glacial	1 Recent 2 Post-glacial 3 Pleistocene	1 Recent 2, 3 Pleistocene	1 Recent 2, 3 Pleistocene
Tertiary	3 Newer Pliocene 4 Older Pliocene 5 Miocene 6 (Oligocene) 7 Eocene	3 Post-pliocene 4 Pliocene 5 Miocene 6 Oligocene 7 Eocene	4 Pliocene 5 Miocene 6 Oligocene 7 Eocene	4 Pliocene 5 Miocene 6 (Oligocene) 7 Eocene	4 Pliocene 5 Miocene 6 Oligocene 7 Eocene

Note.—*The segregation of the Oligocene from the Eocene had not been effected when Lyell and Jukes wrote.*

From the above table it will be noticed that Lyell and Hull assign the Glacial period—called by the former "Newer Pliocene," and by the latter "Post-pliocene"—to Tertiary or pre-human time; and the first appearance of Man in Europe to the period of elevation which followed the submergence at the close of the Great Ice Age, when the climatic conditions and the adaptations of organic nature were becoming more and more favourable to the existence and welfare of the human species. This latter period is called by Sir Charles Lyell Post-pliocene, and by Dr. Hull Post-glacial. Professor Geikie, of the Edinburgh University, also uses the term Post-glacial for Lyell's Post-pliocene; and in his "Outlines of Geology" he expresses the opinion that "the palæolithic inhabitants of Europe settled in that continent during the Glacial period, and had disappeared before the advent of the Post-glacial and Recent period."

In his admirable "Manual of Geology," Mr. J. Beete Jukes, for convenience, embraces the Glacial and Post-glacial under one head —Pleistocene—a term originally employed by Lyell to indicate the Glacial period, but for which he substituted Newer Pliocene, because the late Professor Edward Forbes had used Pleistocene nearly in the same sense as that in which he (Lyell) uses Post-pliocene in his "Antiquity of Man" (Introduction, p. 6).

Dr. Hull adopts the term Post-pliocene instead of Lyell's Newer Pliocene to indicate the Glacial period, and in common with him places it in the *Tertiary* division of strata, while Professor Geikie and Mr. J. B. Jukes tabulate it as a *Post-tertiary* group under the designation of Pleistocene; the latter authority, in common with Professor Prestwich, including the Postpliocene under the same head.

We prefer to follow Jukes, Hull, and Geikie in discarding the term Post-pliocene; and instead of adopting Post-glacial as an equivalent, we propose to substitute Pleistocene. The terminology we suggest will be made plainer by reference to the following table:

Epochs.	Systems or Periods.	Groups and Sub-groups.
Quaternary or Neozoic.	Anthropozoic.	1. Holocene { Historic Prehistoric (Neolithic). 2. Pleistocene, ,, (Palæolithic).
Tertiary or Cainozoic.	Megazoic.	3. Newer Pliocene (Glacial). 4. Older Pliocene. 5. Miocene. 6. Oligocene. 7. Eocene.

For the sake of phraseological sequence, we substitute the term Holocene (all recent) for the incongruous word Recent; and to supply the want of terms for the Tertiary and Post-tertiary *systems*, we distinguish the former as *Megazoic* (gigantic life) and the latter as *Anthropozoic* (human life), to indicate their leading zoological characteristics; and the substitution of Pleistocene for Post-pliocene or Post-glacial we consider an improvement upon the nomenclature verbally, without detriment to its descriptive applicability.

The term Post-glacial, as formerly designating a group, might be objected to; for although there are now no glaciers in Britain, it cannot be doubted that on the reelevation after the general submergence of the ice-clad land at the close of the Newer Pliocene period, glaciers existed in the mountainous districts of Europe, including the British Islands, and had not entirely disappeared before the earliest human inhabitants arrived. From that time to the present glacial conditions have continued in elevated regions of both hemispheres, more especially in the circumpolar zones, whence myriads of icebergs are annually sent off to drop their burden of clay and boulders upon the bed of the ocean ; while in Southern Europe, and even in lower latitudes, we have in the present day illustrations of phenomena due to movements of land-ice.

In human history the recognized median line between ancient and modern is the birth of Christ, and the generally accepted geological boundary between past and present is the advent of Man, an event which marks the commencement of a new epoch of the world's history, distinguished, in continuation of the ordinal classification of strata, as Quaternary, and, as on zoological grounds, Neozoic (new life); for certainly the presence of a rational being was something new and unprecedented; while at the same time the animal and vegetable kingdoms of the period consist of new species directly or indirectly adapted to the wants of the human race—cattle, and smaller quadrupeds fit for food or domestication; food fishes and food fowls, edible fruit, grain-bearing grasses, and herbage.

The term Post-tertiary is also employed to embrace the Neozoic groups, the newer being commonly called Recent, and the older Post-pliocene, terms for which we substitute Holocene and Pleistocene respectively. Some authors would group both Tertiary and Post-tertiary as Cainozoic—a designation under which the Tertiary strata alone are at present embraced; and which was originally adopted by Sir Charles Lyell to indicate the presence, in their groups, of mollusca specifically identical with those now living, their relative prevalence, in certain localities, being shown by the terms *Eocene* (a few recent); than *Miocene* (fewer), *Pliocene* (more); and its *Pleistocene* (most).

Adopting human life as the characteristic feature of the Post-tertiary epoch, we accept Lyell's term "Newer Pliocene" as descriptive of a Tertiary group embracing the lower, middle, and upper stages of the Glacial period, to which we may be justified in adding a fourth or drift stage; for the close of the Tertiary epoch appears to have been signalized by a widespread submergence of the ice-clad land by which its glacial cover was floated off, and carried away on ocean currents to drop its burden of clay and boulders at a distance from their parent source. It is more than probable that during the submergence not a few of the mountain summits of Britain remained above sea-level as islets shrouded in snow and ice, and beset with drifting floes which could not fail to imprint traces of their existence upon the ancient coast-line.

The record of the Newer Pliocene, or Glacial age, however, is involved in considerable obscurity, from the circumstance that both in its earlier and later stages glacial conditions differing in intensity affected a considerable area of both hemispheres, a temperate period intervening. The method, compass, and force of the physical agents in operation during each of its stages form intricate subjects of investigation; and the extent to which the processes in the newer have overlapped, modified, or obliterated the geological features of the older, is not generally agreed on; but much may be learned on the subject of glacial agency from Dr. Archibald Geikie's "Scenery of Scotland," and Mr. Jukes-Browne's "Building of the British Isles," recent works of great merit.

The Quaternary epoch was inaugurated by a reelevation of land, which appears to have been effected by a series of sudden and intermittent movements; but a considerable period must have elapsed before Europe was prepared for the reception of its first human inhabitants; and this, so far as that Continent is concerned, may be regarded as a transition stage between Tertiary and Post-tertiary time; for the successive phases of organic and inorganic nature at all periods of the earth's geological history passed from one to the other, not suddenly and completely, but with the gradual change of climatic and other physical conditions, and the successive extinction of organisms characteristic of the older, and the gradual substitution of their successors in the newer order of things.

The close of the "drift" introduces us into what Lyell calls the Post-pliocene period, but which we denominate Pleistocene, when the existing terrestrial areas which had been submerged were developed and readjusted by repeated upheavals registered by a series of geological landmarks well known to science, every successive elevation increasing the extent of the low, fertile land, producing an important alteration of the coast-line, and relatively reducing the area under glacial conditions, which at last passed away, with certain exceptions, under the combined influence of the local and general physical causes by which climates are effected.

Although Man found his way into Europe long before it had attained its present development, when the climate was more ungenial, it may have been a considerable time after the elevatory movement began. This period of elevation, in the course of which Man made his appearance in Europe, as already stated, we denominate Pleistocene, as equivalent to Post-pliocene, and Post-glacial, and descriptive of the oldest group of the Anthropozoic system. This base line for the human period, however, must be understood as provisional, for geological authorities differ in opinion as to the particular stage of time which furnishes the earliest proofs of Man's presence, some insisting that he was a denizen of Europe during, or even before, the Great Ice Age; but the evidence in favour of this opinion is not so satisfactory as could be desired, and there is ample room for additional proof; so that in the meantime we may consider the question whether or not Man existed before, or during, the Glacial period as unsettled.

In the Pleistocene (Post-pliocene) period there were associated with Man in Europe certain species of Tertiary mammals now extinct, while others of Neozoic origin, now living, coexisted with them; and this is not to be wondered at, for in the more ancient geological systems many genera and species ranged from the older to the newer, and were for a time contemporary with more recent forms of life. In the newer stage of the Post-tertiary epoch (*Holocene*) are classed the deposits in which *no extinct species* have been found. This group is divided into Historic and Pre-historic sub-groups; and to the latter belong the polished implements of Neolithic age, while the unpolished weapons belong to the older stage of Post-tertiary time (Pleistocene) known also as the Palæolithic or *ancient stone* period, to distinguish it from the Neolithic, or *new stone* period. The more recent of these periods, however, may be divided into an older and a newer stage, indicating an advance in culture, as illustrated by the relics found on the shores of the Danish islands.

V.—The Rocks of St. Davids.

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

In a characteristic article by Prof. Blake, "On the Base of the Sedimentary Series in England and Wales," in the July Number of the Geological Magazine, amongst other erroneous statements, there is one which I must beg leave to correct. At page 310, in referring to the rocks of St. Davids, he makes the following statement: "While accepting the *later* petrological descriptions of Dr. Hicks, he (Dr. Geikie) minimized the separation between this [the Pebidian] and the Cambrian conglomerate, and challenged Dr. Hicks to prove his statement that the latter is chiefly composed of fragments of the rock on which it lies. This Dr. Hicks has never been able to do, seeing that the most marked feature of the conglomerate is that it is *not* composed of such fragments; instead of doing so, he now attempts to show that the matrix might have been derived from granitoid rocks."

One would never have supposed that any geologist who had made even a most imperfect examination of the district, and had but a slight acquaintance with the literature of the subject, would have ventured to make such a reckless assertion, especially after the published notes by such eminent petrologists as Prof. Bonney and Mr. Davies in the Q.J.G.S. vols. xl. and xlii., which give abundant examples to show that the Cambrian conglomerates contain fragments identical with the rocks underlying them. Moreover, at Ramsay Island, Trefgarn, and elsewhere, three-fourths of the pebbles in the conglomerate must have been derived from the rocks immediately below. In the Q.J.G.S. vol. xlii. p. 358, Prof. Bonney says, "The sections contain numerous fragments of felspar, very similar to that in the Dimetian; in short, they present every appearance of an 'arkose' to which granitoid rocks have largely contributed. Six out of the seven slides include well-marked fragments of granitoid rock. . . . . . In all respects the section of this fragment curiously resembles the slides of 'Dimetian' rock." Again, at p. 362, he gives the following as his conclusions:—

"A. When the Chanter's Seat conglomerate was formed the following rocks were undergoing denudation:—
(1) Granitoid rocks, identical with the existing Dimetian.
(2) Trachytic rocks, among which were probably true lava-flows.
(3) Quartzites and schists, the latter resembling those which in many districts occur rather high in the Archæan series.
(4) Ordinary sedimentary rocks.

Hence there was in this district a series of rocks, some much older than others, which contributed to the formation of the Cambrian conglomerate.

B. The conglomerate above the Trefgarn series is formed from rocks which occur in the latter.

C. The peculiar characteristics distinctive of certain members of the Trefgarn series had been assumed by them when the conglomerate was formed.

D. Either the Dimetian is a member of an old gneissoid series or, if it is the core of a volcanic group from which the trachytic lavas had been ejected, this had been laid bare by denudation before the Cambrian conglomerate was formed. Hence in either case both the Dimetian and the felstones are Pre-Cambrian."

In the Q.J.G.S. vol. xl. Mr. T. Davies, in addition to describing numerous slides prepared from pebbles of felsites, quartz-felsites, basic volcanic rocks, porcellanites, etc., derived from the Cambrian Conglomerates and proved to be identical with the rocks of that character in the Pebidian series, makes the following statement, at p. 555, concerning the fragments of Dimetian in the conglomerate: "The view that the Cambrian conglomerate of St. Davids incloses much waterworn débris of the Dimetian is, I think, fully justified by the evidence now adduced from the examination of many slides of this rock, few of which have failed to afford evidence of the presence, not only of pebbles of a rock, which under the microscope could not be distinguished from it, but also of its individual mineral constituents. The slides examined and described here are not selected ones, but have been taken as they were cut. The peculiar quartz of the Dimetian, thronged as it is with extremely minute inclosures other than fluid, causing its well-known dirty aspect, is abundant. The felspars of both rocks are of the same character and habit, although necessarily more fragmentary in the conglomerate. Though not abundant, they are there, and can be most distinctly recognized. In some cases they are not more altered than in the Dimetian; but in others the structure has entirely disappeared, leaving a kaoline-like mass which feebly depolarizes light."

I may add that I am quite ready to submit the slides on which the above statements were founded, along with others since prepared, if possible containing still more conclusive evidence, to any unbiassed petrologist.

VI.—Note on certain Teeth referred to *Hyænodon indicus*.

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

In the "Palæontologia Indica," ser. 10, vol. ii. p. 349, fig. 21, I described and figured a lower premolar from the Siwaliks of the Punjab, under the name of *Hyænodon indicus*; the figure being reproduced in the accompanying woodcut (Fig. 1).

On the same and following pages I described two other teeth (figured in plate xliii. figs. 5, 6 of the same memoir), which were

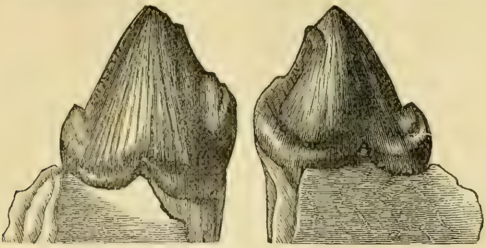

FIG. 1.—Fourth left[1] lower premolar of *Hyænodon indicus*. $\frac{1}{1}$.

regarded as lower molars of a Carnivore. It was suggested that these teeth might belong to *Hyænodon indicus*, in which event that species would have to be transferred to another genus. Subsequently, in the "Cat. Foss. Mamm. Brit. Mus.," pt. 1, p. 32, fig. 2, I described and figured an imperfect tooth from the Quercy Phosphorites very similar to the problematical Indian teeth, and which was considered to indicate an allied form.

FIG. 2.—Inner and oral views of the imperfect right upper carnassial of *Amphicyon ambiguus*. $\frac{1}{1}$.

Subsequent observations (for which I am indebted to a friend) have shown that I was totally mistaken in regard to the nature of these teeth. They are really imperfect upper carnassials of extinct Dogs, in which the inner tubercle has been broken away, and which I have figured the wrong way upwards. This will be apparent from Fig. 2, which is a reproduction of the figure of the Quercy tooth now turned the right way upwards. The Quercy specimen belongs to *Amphicyon ambiguus*, while the Indian teeth may be referred to *A. palæindicus*.

Finally, it may be well to mention that I see no reason to alter my opinion that the type of *Hyænodon indicus* (Fig. 1) indicates a Creodont either generically identical with or very closely allied to the Eocene species of *Hyænodon*.

VII.—NOTE ON THE ELEVATION OF THE WEALD.

By the REV. A. IRVING, D.Sc. (Lond.), F.G.S.;
of Wellington College, Berks.

FEW students of Geology can doubt that the elevation of the Weald has been the most important factor concerned in determining the present surface-geology of the south-east of England. It has been constantly before my own mind in all my studies of Tertiary Geology for the last ten years, as the problem to the solution of which many other preliminary questions required

[1] In the original figure it is wrongly described as of the right side.

answers. In my first paper[1] on Tertiary Geology, read before the Geologists' Association in 1883, I pointed out that the presence of Eocene pebble-beds in the Woolwich and Reading series and in the Bagshot series afforded strong evidence of the encroachment of the sea upon the Upper Chalk in Eocene times. This conclusion is accepted by our greatest authority on Tertiary Geology, Prof. Prestwich.[2] The fact alone furnishes a strong presumption that the elevation of the Weald had commenced before the close of the Eocene period; while the many outliers of the Woolwich and Reading beds at high altitudes on the N. Downs, taken along with the general absence of the London Clay there, seems to tell us that the initial elevation of the Weald hill-range had gone far enough for this to form a shore to the area of deposition of the London Clay. I have shown further, in a former volume of the Geol. Mag.,[3] that, though there is no absolute proof, there are grounds for believing, that certain outliers of sands on the N. Downs (at Chipstead, Headley, and north of Netley Heath) are more likely to turn out to be of Upper Eocene age, than of any age to which they had been hitherto assigned by different writers. There is here the strong presumptive evidence of the lithological similarity to the Upper Bagshot, in most cases amounting almost to identity. In the Headley sections, as I saw them, there was just that difference in the beds being thinner than is usual in the Upper Bagshot, and at the same time the presence of a few scattered small unworn flints in the sands, which made me speak of them with more reserve; but which further consideration has suggested may be only just those differentiæ which may be explained by greater proximity to a shore, where the Chalk was undergoing destruction and furnishing the flints. On the other hand, there was on the surface what appeared to be the wreckage of a Bagshot pebble-bed at Headley, which suggests the Lower Bagshot as the more probable horizon for the sands at that place. Still these facts taken together do not of course militate against the view that the sands at the various localities mentioned may be of Upper Eocene (Bagshot) age.

To the minds of some the question as to age of these beds may appear to have been definitely settled, now that the Lenham deposits are shown to be of Diestian age, *i.e.* Older Pliocene.[4] This, of course, depends upon the contemporaneity of these deposits with the Lenham beds (some fifty miles further to the east) being established. This contemporaneity has been generally assumed on the ground of approximate equality of altitude above the sea; but this, after all, may be *a mere accident*, and if so any argument based on the assumption must give way; the chain cannot be stronger than than its weakest link. This assumption seems to be based on the further assumption that the elevation of the Weald has been

[1] On the Bagshot Beds of the London Basin and their associated Gravels, Proc. Geol. Assoc. vol. viii. pp. 143–171.
[2] Q.J.G.S. vol. xlvi. pp. 116, 167.
[3] See Geol. Mag. Dec. III. Vol. V. (1888), pp. 183, 184.
[4] See Mr. Clement Reid's communication to *Nature* (1886), vol. xxxiv. pp. 341–2.

simultaneously commensurate throughout the whole distance from east to west; but I think it can be shown that there are fairly strong grounds for doubting this.

1. We have the record of at least two important lines of movement: (*a*) the Isle of Wight and Purbeck anticlinal; (*b*) the anticlinal axis of Kingsclere and Inkpen—the latter probably initiated at the age of the Upper Chalk as worked out by Dr. Barrois.[1] The former of these must have been initiated at about the beginning of the Oligocene period, in order to account for the relative lie and position of the Eocene and Oligocene strata of the island:[2] the latter (as I have previously pointed out elsewhere[3]) was, in all probability, somewhat advanced in later Eocene time.

Along each of the lines of movement the strata have been thrown into a position of much greater inclination on the north than on the south side. This seems to follow as a simple mechanical result of the resistance offered by the greater proximity of the great Mesozoic area (and perhaps the underground conformation of the Palæozoic rocks) of central Mercian England. Such movements could scarcely leave the western end of the Weald unaffected. These conditions fail when we attempt to apply them to the eastern part of the Weald. There are also such minor axes of elevation as those of Winchester and Portsdown, probably later Eocene.[4]

2. An examination of the stratigraphical structure of the Weald shows that the resultant displacement of the strata in the western part of the Weald is greater than that of the eastern part. This is well seen in the high angle of inclination of the chalk of the Hog's Back, and of the Neocomian strata of the Hindhead anticlinal.[5] It is reasonable to suppose that these recorded movements were initiated much earlier than those which have brought up the strata of the eastern part of the Weald to their present position; and this supposition is supported by the fact that the general axis of elevation of the Weald, which can be traced from its exposure in the cliffs east of Hastings, through Crowborough Beacon (the highest point in the Hastings Sands), Horsham, and Petersfield,[6] seems to be independent of, and posterior to, certain earlier movements which determined the initiatory stages of elevation of Hog's Back and Hindhead.

3. Mr. Topley,[7] has given us a table of *culminating points* of the chief formations of the Weald, showing, for each of the formations, the Chalk (both north and south), the Lower Greensand, and the Hastings Beds—"a general fall of the summits" from west to east; a result scarcely to be accounted for by greater denudation towards the east, but probably connected with the greater disturbance to which the western part of the Weald has been subjected. It is in

[1] See "Récherches sur le Terrain Cretacé superieur," figures 4 and 8 on the plate at the end; also p. 113.

[2] See (*e.g.*) the section (No. 3) of Ramsay's Geological Map of England and Wales.

[3] Q.J.G.S. vol. xliv. p. 181.

[4] Barrois, *op. cit.* p. 115.

[5] See Topley, "Geology of the Weald," p. 232.

[6] Topley, *ibid.*

[7] *Ibid*, pp. 240, 241.

the western part of the Weald too (*e.g.* at Leith Hill and near Farnham) that the same authority [1] tells us that the greatest amount of dislocation occurs; the faults recorded at these two localities being apparently connected with the Hog's Back line of elevation, as is also another south of St. Martha's, near Guildford.

4. The chief *transverse synclinals* of the Weald are those of the valleys of the Medway and the Stour on the north-east side, and of the Adur and the Arun on the south side; while there appears to be an absence of such synclinals on the north side of the western part of the Weald.[2] This looks very much as if they were formed in a series of later movements caused by forces acting from the south-east or east, and not affecting the previously-elevated portions of the Weald to the north-west.

5. The fact that the raised beaches rise as they are traced west, till at Bourne Common, near Goodwood, they are 130 feet higher than at Brighton,[3] has been pointed out by Mr. Topley as showing greater western elevation.

A progressive elevation of the English portion of the Weald from west to east, such as the facts advanced above would seem to indicate, leads of necessity to the conclusion that the assumption (which has so often been made in certain quarters) that the mere accident of the Lenham deposits being now at almost the same elevation as certain outliers at Chipstead, Headley, and on the north side of Netley Heath, points to their contemporaneous age, is scarcely tenable. For, if such an elevation went on progressively in the direction indicated, it may well have happened that those outliers of sands may represent transgressive portions of the later Eocene, and have been raised above sea-level during Miocene or early Pliocene times, while the north-eastern portion of what is now the Weald was still beneath the waters of the Pliocene sea, and receiving deposits, of which remains are preserved to us in the hollows of the Chalk at Lenham. The general strike of the strata from the valley of the Medway to Folkestone seems to favour this view.

A little reflection will show that the same negative reasoning applies to the rather characterless plateau-gravel described by Prof. Prestwich [4] as occurring on the hills west of Canterbury. There is nothing in the nature of things to necessitate contemporaneity, though similar causes acting under similar conditions have produced similar results; on the other hand, there are, as we have seen, facts which militate against the assumption of contemporaneity of similar deposits situate so far as these are from those of East Berks and West Surrey, notwithstanding the fact that they are all of pre-Quaternary age.

But I think there is not wanting evidence of a more general nature, tending to show that the Wealden area must have made some advance towards the position of a hill-range before the close of the Eocene period. This evidence is found in (i) the high inclination of the Lower Eocene strata along the northern flank, as seen at Highclere; (ii) the shallowing of the waters of the

[1] *Ibid*, pp. 230, 232, 233.
[2] Topley, *Ibid*, pp. 277, 278.
[3] *Ibid*, p. 286.
[4] Q.J.G.S. vol. xlvi. p. 156; see also pl. viii.

Anglo-Gallic sea and deposition of the Oligocene strata, with which the Tertiary record closes in the Paris and Hampshire Basins; (iii) the absence of marine deposits of Miocene age; (iv) the great palæontological break between the Oligocene and the Crag, "not a single species in any class being common to these two series in Britain."[1] Further reflection during recent years upon the significant fact, that we have no trace of Miocene marine deposits in the South-East of England, has led me to the conclusion that the Wealden and Tamisian areas were "dry land," and therefore undergoing subaërial waste and degradation all through that period of geologic time and on into the Pliocene, as, in fact, Prof. Zittel has represented matters in his Map of Middle Europe in Miocene times.[2] Mr. Etheridge appears to have arrived at the same conclusion, as he has remarked (*op. cit.* p. 651), "Britain, so far as we know, was a land-surface forming part of the continent during part of the Miocene period." We may therefore hesitate to follow Professor Prestwich in dating the great elevation of the Weald posterior to the Miocene.[3] The commencement of this elevation is referred by Zittel (*op. cit.* p. 433) to the Oligocene period, a simultaneous depression of North Germany occurring, so that the waters of the North Sea overflowed that region as far south as Bonn, and washed the flanks of the Hartz and Thuringian mountains. Credner[4] gives a more detailed description of this, and tells us that this depression continued on a more restricted scale during the Miocene, the Tertiary deposits of North Germany being exclusively of Oligocene and Miocene age, the Oligocene strata of that region being partly marine, partly terrestrial, the latter yielding the chief supply of brown-coal. At various points in North-western Germany — Schleswig, Holstein, Lauenburg, West Mecklenburg, Northern Hanover—Miocene strata are recognized; and they appear to stretch away to the south-west through Oldenburg and Westphalia to Hasselt and Antwerp, being recognized by Von Koenen as contemporaneous deposits, differing only in their physical facies from those of his Diestian and Bolderian system.[5] This Miocene and early Pliocene basin may represent the area of depression on the north side of the region of Miocene elevation (which included the present regions of the Weald, the English Channel in its eastern portion, and the north of France), and seems to have corresponded with a similar depression of the Loire basin, where the Tertiary record commences with the Miocene. These alterations of level were some of the minor incidents of those great changes of contour of Central and Western Europe, which are recorded in the Alps and Carpathians, and perhaps most markedly in the Pyrenees (where the Nummulitic Limestone is lifted up to the crests of mountains more than 10,000

[1] Etheridge, "Manual of Geology," p. 652.

[2] "Aus der Urzeit" (Oldenbourg, Munich), p. 459.

[3] See also Ramsay, "Phys. Geol. and Geog. of Great Britain" (5th ed.), pp. 274, 356.

[4] "Elemente der Geologie" (6th ed.), pp. 695–703.

[5] Credner, *op. cit.* p. 714. If we follow Mr. C. Reid in relegating the Diestian to the older Pliocene, these North German deposits may be of Pliocene age also; but this is a detail which does not much affect the general argument.

feet above the sea, while the Miocene strata lie horizontally against the highly inclined older strata on the north side),[1] changes which effectually mark off the Older from the Younger Tertiaries of Europe.

A gradual subsidence during Pliocene time of the Tamisian area would admit of the extension of the northern waters again to the west, so as to cover a portion of the East Anglian area, and give us the Crag deposits in a shallow sea bounded on the west and south by a zone of older Tertiaries, across which there must have been extensive transport of detritus from the elevated Cretaceous regions of East Mercian England on the north-western side, and the Weald on the southern side. These seem to me to have been approximately the physiographic condition under which the plateau-gravels north of the Thames were accumulated. And if this were so, there is no real necessity for associating the Westleton Shingle of Prestwich with the plateau-gravels on the south of the Thames; for the flint pebbles and fragments of the former were in all probability derived from the Chalk of Norfolk and Suffolk.[2] The list of organic remains of the Westleton and Mundesley Beds, given by Prof. Prestwich in Part I. of his recent paper, shows such a preponderance of land- and fresh-water-remains as to suggest an estuarine origin for these beds; so that we might not be very far wrong if we regarded them as accumulated at the beginning of the Quaternary period near the western margin of the older Rhine estuary, which received the drainage of the East Anglian and lower Tamisian areas.

The admission that the inland representatives of the Westleton and Mundesley shingle-beds may be of terrestrial origin, similar to that which is assigned to the plateau-gravels on the south side of the Thames, would remove two difficulties, which must, I think, have presented themselves to the minds of others besides myself:— (1) It is difficult to accept the view of such a wide-spread marine floor at about the beginning of the Quaternary period, as would extend the waters of the German Ocean to the flanks of the Cotswolds, with a subsequent elevation towards the west of some 500 feet, unless independent and collateral evidence of a less equivocal nature can be adduced in support of the hypothesis. (2) There is a great difficulty in explaining the unfossiliferous character of those inland gravels, on the theory of 'decalcification'; since so many of them are covered (as shown in Prof. Prestwich's sections [4]) by Boulder-clay, which must have served as an impervious protection to them from the action of atmospheric carbonated waters. It is somewhat curious that this theory of decalcification has been applied where it will not very well work, but not to the plateau-gravels of the Southern Drift, where the same difficulty does not arise.

The recognition of the Pliocene age of those inland gravels and sands, and of their terrestrial origin, would give us also a wide limit of time for the formation of the East Mercian Chalk Escarpment, and of the present valley-system, and so remove a still further difficulty.

[1] Credner, *op. cit.* p. 722.

[2] The inference fairly to be drawn from the absence of Tertiary deposits in the Midland and Northern Counties is in accordance with this view.

[3] See Q.J.G.S. vol. xlvi. pp. 115-117.

[4] Q.J.G.S. *loc. cit.*

A Miocene elevation of the Weald and of East Mercian England, such as has been here suggested, would allow that longer period of time for the subaërial waste of the Chalk, which is required to account for the angular flint fragments of the plateau-gravels, especially as we see them on the hills above Aldershot, where the materials have not been transported very far. On the Chalk Downs above Ventnor we see them still in position, just as they are left by the solution of a chalk matrix with very little argillaceous material. It seems probable that the materials thus furnished may have acquired the subangular form which they exhibit in the plateau-gravels of the Southern Drift during their transport northwards in Pliocene times, owing perhaps to accentuation of the anticline of the Weald at that period, and its elevation into a more definite hill-range, causing an increase of precipitation and a greater volume and rapidity of flow, with a correspondingly greater transporting power, of the rivers which flowed from it, to convey the flinty materials of the plateau-gravels, along with the débris of Neocomian rocks.

These are little more than suggestions, but perhaps worthy of consideration. I do not think they have been sufficiently considered in connection with the general problem; and this may be a justification for the appearance of this short paper.

VIII.—On Some Small Bivalve Shells from the Karoo Formation, South Africa.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

Amongst the specimens sent many years ago, from South Africa, by the late Mr. Andrew Geddes Bain, to the Geological Society of London, are two small blocks of greenish-grey hard mudstone or shale, very slightly calcareous; one bed-plane in each specimen bears upon its surface numerous valves of one or more forms of small Lamellibranchs, closely resembling the shells of the genera *Cyrena* and *Cyclas* in contour.

The longest axis of one of the largest and best-preserved individuals is 7 millimètres, the shorter 5 mm. A smaller, well-shaped form measures 5 mm. by 4·5 mm. Only in a few instances has it been found possible to develope these little valves from their matrix, so as to show their contours clearly and accurately.

Within certain limits, these little shells vary much in size and contour, as the following measurements numerically express in mm.:

From the anterior to the posterior margin of valve.		From the umbo to the ventral margin of valve.
3	×	2½
3½	×	2½
4½	×	3
5	×	4½
5	×	5
6	×	4
6	×	5
7	×	4
7	×	5
7	×	5¼
8	×	5 (lengthened by crush).

The specimens are brown casts, having the surface concentrically wrinkled, with lines of growth rather numerous, sometimes strong, and often irregular, apparently from pressure on a thin shell. This, if once calcareous, has disappeared, leaving a brown film externally, and a thin dark line, where it has been broken across, in the stone. They remind us, in general appearance, of similar shells in the English Wealden.

The shape varies from suborbicular to oval, suboval, and trigonal; some have evidently been shortened and others lengthened by pressure. One specimen has obscure remnants of a hinge, showing traces of cardinal and lateral teeth.

It occurs to me that these small Bivalves may be conveniently referred to *Cycladidæ*, and probably more nearly allied to *Cyrena* than to *Cyclas*. Hence we may provisionally name them *Cyrena*? *neglecta*.

These two little blocks of Karoo stone were collected by Mr. Bain at the village of Balfour, on the right bank of the Kat River, 400 yards north of the Rev. Mr. Thompson's house, and are preserved in the Museum of the Geological Society, London.

A portion of one of the blocks from the Kat River, Eastern Province, South Africa, showing four of the small shells and parts and sections of others; magnified twice the natural size.

These differ from the four South-African "*Cyrenæ*" (?) figured and described or noticed by D. Sharpe in the Trans. Geol. Soc. ser. 2, vol. vii. pp. 199, 202, and 225, pl. 28, figs. 7, 8, 9, and 13. Fig. 7 (undetermined) is from the same great Karoo formation, further north, at Graaf Reinet; but figs. 8 and 9 (undetermined), and 13 (*Cyrena*? *Bainii*) are from a different series of strata on the Zwartkop River.

IX.—Fossil Types in the Bristol Museum.

By E. Wilson, F.G.S.;
Curator of the Bristol Museum.

(*Concluded from the August Number, page* 372.)

Pelecypoda—*continued.*

Lucina pisum, J. de C. Sowerby (non d'Orbigny) (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvi. f. 14; F. Stoliczka, Cret. Pel. of S. India, p. 252 [valves united]. Up. Greensand, Blackdown.

Macrodon ? rapidus, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 521, pl. xviii. f. 3 (in part type) [right valve]. Inf. Ool. Dundry.

Macrodon rasilis, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 521, pl. xvi. fs. 15, 15*a*, 15*b* [right valve]. Inf. Ool. Bradford Abbas.

Mactra? angulata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvi. f. 9; F. Stoliczka, Cret. Pel. of S. India, p. 55 [valves united]. Up. Greensand, Blackdown.

Modiola reversa, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 13; F. Stoliczka, Cret. Pel. of S. India, p. 373 [right valve]. Up. Greensand, Blackdown.

Modiolopsis acutiprora, W. J. Sollas, Q.J.G.S. vol. xxxv. p. 426, pl. xxiv. fs. 21, 22 [left valve, 2 casts and 1 mould in gutta-percha]. Wenlock, Rhymney Quarry, Cardiff.

Mya læviuscula, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 340, pl. xvi. f. 6 [right valve]. Up. Greensand, Blackdown.

Myoconcha unguis, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 530, pl. xviii. f. 21 [left valve]. Inf. Ool. Dundry.

Mytilus inæquivalvis, J de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 16; syn. of *M. lanceolatus*, Sow. Min. Conch. pl. 439, f. 2; F. Stoliczka, Cret. Pel. of S. India, p. 372. Up. Greensand, Blackdown.

Mytilus prælongus, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 15; syn. of *M. lanceolatus*, Sow., d'Orbigny, Terr. Cret. vol. iii. p. 270; F. Stoliczka, Cret. Pel. of S. India, p. 372 [left valve]. Up. Greensand, Blackdown.

Mytilus striatissimus, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 519, pl. xvi. f. 12 [right valve]. Inf. Ool. Dundry.

Mytilus tridens, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 14; syn. of *M. lanceolatus*, Sow., d'Orbigny, Terr. Cret. vol. iii. p. 270; F. Stoliczka, Cret. Pel. of India, p. 372 [double valve and left valve]. Up. Greensand, Blackdown.

Nucula lineata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 9; *Nuculina*, F. Stoliczka, Cret. Pel. of S. India, p. 326; *Leda*, W. Downes, Q.J.G.S. vol. xxxviii. p. 88; J. S. Gardner, Q.J.G.S. vol. xl. p. 136 [double shell and left valve]. Up. Greensand, Blackdown.

Nucula nuciformis, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 525, pl. xviii. fs. 5, 5*a* [valves united]. Inf. Ool. Dundry.

Nucula obtusa, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 11; F. Stoliczka, Cret. Pel. of S. India, p. 326; J. S. Gardner, Q.J.G.S. vol. xl. p. 126 [left valve]. Up. Greensand, Blackdown.

Orthonota navicula, W. J. Sollas, Q.J.G.S. vol. xxxv. p. 496, pl. xxiv. f. 3 [valves united]. Up. Ludlow, Cross Dowton, Rhymney.

Panopæa ovalis, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 340, pl. xvi. f. 5; *Myacites*, J. Morris, Cat. Brit. Foss. 2nd ed. p. 214; *Panopæa*, F. Stoliczka, Cret. Pel. of S. India, p. 87 [valves united]. Upper Greensand, Blackdown.

Pecten barbatus, J. Sowerby, Min. Conch. pl. 231 [natural mould]. Inf. Ool. Dundry.

Pecten compositus, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342. pl. xvii. f. 20; F. Stoliczka, Cret. Pel. of S. India, p. 428 [single valve]. Up. Greensand, Blackdown.

Pecten Millerii, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 19; F. Stoliczka, Cret. Pel. of S. India, p. 428 [left valve]. Up. Greensand, Blackdown.

Pecten Stutchburianus, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xviii. f. 1; F. Stoliczka, Cret. Pel. of S. India, p. 428 [imperfect shell]. Upper Greensand, Blackdown.

Petricola? *canaliculata*, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvi. f. 10; *Acanthocardium* (*Cardium*), F. Stoliczka, Cret. Pel. of S. India, pp. 141, 213 [right valve]. Up. Greensand, Blackdown.

Pholadomya spatiosa, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 534, pl. xix. f. 11 [valves united]. Inf. Ool. Dundry.

Thracia leguminosa, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 531, pl. xviii. fs. 23, 23*a* [valves united]. Inf. Ool. Dundry.

Trigonia quadrata, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 12; syn. of *Trigonia dædalea*, Parkinson, J. Lycett, Brit. Foss. Trigoniæ, Pal. Soc. p. 100 [right and left valves]. Up. Greensand, Blackdown.

Venus immersa, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 6; ? *Cyprimeria* or *Cytherea*, F. Stoliczka, Cret. Pel. of S. India, p. 161 [valves united]. Up. Greensand, Blackdown.

Venus sublævis, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 342, pl. xvii. f. 5; *Cytherea*, F. Stoliczka, Cret. Pel. of S. India, p. 161 [left valve]. Upper Greensand, Blackdown.

Venus? *truncata*, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 341, pl. xvii. f. 3; *Cytherea*, J. Morris, Cat. Brit. Foss. 2nd ed. p. 201; *Caryatis*, F. Stoliczka, Cret. Pel. of S. India, p. 161. Upper Greensand, Blackdown.

Brachiopoda.

Rhynchonella Dundriensis, S. S. Buckman, Proc. Dorset Nat. Hist. Club, vol. iv. p. 43 (1882); *Rhynchonella*, sp. T. Davidson, Brit. Foss. Brach. Pal. Soc. vol. i. Appendix, pl. A. f. 28; *Rh. Dundriensis*, Buckman, T. Davidson, Appendix to Supplement Brit. Foss. Brach. vol. v. p. 272, pl. xix. f. 10 [valves united]. Inf. Ool. Dundry.

Terebratula Etheridgii, T. Davidson, Brit. Foss. Brach. Pal. Soc. vol. i. Appendix, p. xx. pl. A. fs. 7, 8 [valves united]. Inf. Ool. Dundry.

Terebratula? *megatrema*?, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 3; *Argiope*, T. Davidson, Brit. Foss. Brach. Pal. Soc. vol. i. Cret. Brach. p. 101, pl. xii. f. 31? (non f. 32), [valves united, valves gaping]. Upper Greensand, Warminster.

Note.—There is some doubt as to this being the type. The specimen in the Bristol Museum so referred is stated to have come from "Warminster," but Sowerby gives "Blackdown" as the locality of his type. The specimen in this Museum agrees very well with Sowerby's figure, and also with Davidson's reproduction of the same (fig. 31, supra), but not with fig. 32, the specimen stated by him to be in the Bristol Museum.

Terebratula punctata, var. *Radstockensis*, T. Davidson, Supplement to Brit. Jur. and Trias. Brach. Pal. Soc. vol. iv. p. 131, pl. xvi. f. 14 (pars.) [valves united]. M. Lias, Radstock.

Crustacea.

Tropifer lævis, C. Gould, Q.J.G.S. vol. xiii. p. 360, woodcut, fs. 1, 2, 3; H. Woodward, Cat. Brit. Foss Crust. B. M. p. 16 [carapace, 4 abdominal segments and fragment of limb]. Rhætic (bone-bed), Aust Cliff.

Note.—This interesting little crustacean is imbedded in a coprolite and must therefore have served as the food of some fish of the Rhætic period.

Annelida.

Serpula filiformis, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 340, pl. xvi. f. 12. Up. Greensand, Blackdown.

Serpula tuba, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 340, pl. xvi. f. 3. Up. Greensand, Blackdown.

Serpula vermes, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 340, pl. xvi. f. 4. Up. Greensand, Blackdown.

Crinoidea.

Pentacrinus Millerii, T. and T. Austin, Mono. Crinoidea, p. 120, pl. xvi. f. 1*a*; syn. *P. scalaris*, Goldfuss [branching arms]. Gt. Ool. Lansdown, near Bath.

Periechocrinus ? articulosus, T. and T. Austin, Ann. Mag. Nat. Hist. vol. xi. (1843), p. 204 (probably the type) [calyx]. Wenlock. Dudley.

Periechocrinus ? globosus, T. and T. Austin, Ann. Mag. Nat. Hist. vol. xi. (1843), p. 204 (? the type) [portion of calyx]. Up. Silurian. Glyddon Hill.

Platycrinus anthelionites, T. and T. Austin, Ann. Mag. Nat. Hist. vol. xi. (1843), p. 199. Mono. Crinoidea, p. 27, pl. ii. f. 3*m*; syn. of *Pl. pileatus*, Goldfuss; Morris; Cat. second ed. p. 87 [calyx]. Carb. Limest. ? Loc.

Actinozoa.

Montlivaltia Stutchburyi, M. Edwards and J. Haime, Brit. Foss. Corals, Pal. Soc. p. 131, pl. xxvii. f. 3. Inf. Ool. Nunney, near Frome.

Plantæ.

Megaphyton elongatum, R. Kidston, Trans. Roy. Soc. Edinburgh, vol. xxxiii. pt. 2, p. 390, pl. xxvi. f. 1. Coal Measures, Radstock ?

Described and Figured Fossils (other than Type Specimens) in the Bristol Museum.

Mammalia.

Canis lupus, Linnæus, "Wolf" and "Small Wolf," J. Cottle, The Oreston Caves, folio ed. pl. v. f. 8; pl. iii. fs. 3, 4; pl. iv. f. 4 [portions of upper jaw with four molar teeth, humerus, ulna, os calcis and astragalus]. Pleist. (Cave-earth), Oreston Caves, Plymouth.

Canis vulpes, Linnæus, "Fox," J. Cottle, The Oreston Caves, folio ed. pl. iv. f. 5 [fragmentary ulna]. Pleist. (Cave-earth), Oreston Caves, Plymouth.

Elephas (Euelephas) antiquus, H. Falconer, Q.J.G.S. vol. xiii. p. 319; Palæont. Memoirs of Hugh Falconer, vol. ii. p. 179 (not figured) [2nd with molar, left side lower jaw]. Pleist. (cave earth), Durdham Down Cave, near Bristol.

Equus caballus, Linnæus, "Horse," J. Cottle, The Oreston Caves, folio edition, pl. ii. f. 1 [fragment of lower jaw with three incisor teeth]. Pleist. (Cave-earth), Oreston Caves, Plymouth.

Felis leo, Linnæus = *F. spelæa*, Goldfuss, "Tiger," J. Cottle, The Oreston Caves, folio ed. pl. i. f. 6, and pl. iii. f. 1. [fragment of upper jaw with 4th præ-molar and humerus]. Pleist. (Cave-earth), Oreston Caves, Plymouth.

Rhinoceros hemitœchus, H. Falconer, Palæont. Mem. of Hugh Falconer, vol. ii. p. 349 (not figured); syn. of *Rh. leptorhinus*, Owen; R. Lydekker, Cat. Foss. Mam. B.M. pt. ii. p. 101 [worn upper molar teeth, viz. 2nd and 3rd molars, and left antepenult. and penult. true molars, and two premolars in pairs]. Pleist. (Cave-earth), Durdham Down Cave, near Bristol.

Sus scrofa, Linnæus, "Hog," W. Buckland, Reliq. Diluv. pp. 57-59, pl. xi. fs. 30-33 [molar teeth and canine tooth of upper jaw]. In the "Catcott Cabinet," formerly deposited in the Bristol City Library and now in the Bristol Museum. Pleist. (Cave-earth), Hutton Cave, Mendip Hills.

Pisces.

Cladodus conicus ? L. Agassiz, Poiss. Foss. vol. iii. p. 199 (not figured), [tooth in matrix divided longitudinally]. Millstone Grit, ? Honeypen Quarry, Bristol.

Note.—Possibly this is the imperfectly-preserved specimen referred probably to this species by Agassiz.

Cladodus Milleri, L. Agassiz = *Cl. mirabilis*, Agass., J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 378, pl. xlix. f. 16 [tooth in matrix shown in longit. section]. Carb. Limest. (black rock), ? Avon Gorge, Clifton.

Ctenacanthus tenuistriatus, L. Agassiz, J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 335, pl. xliii. fs. 2, 2*a*, 2*b*; syn. of *Ct. major*, Agass., A. S. Woodward and C. D. Sherborn, Brit. Foss. Vert. p. 49 [dorsal spine]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Orodus cinctus, L. Agassiz, J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 392, pl. l. f. 8 [a series of 4 teeth]. L. Limest. Shales (bone bed) Avon Gorge, Clifton.

Orodus ramosus, L. Agassiz, J. W. Davis, Scient. Trans. Roy. Dublin Soc, vol. i. ser. ii. p. 390, pl. l. fs. 1, 2, 5*a*, *b* [series of 3 teeth and single tooth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Psammodus rugosus, L. Agassiz, J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 459, pl. lvi. f. 6 and pl. lvii. f. 1 [teeth]. Carb. Limest., Armagh and Clifton.

Note.—Plate lvi. f. 6 represents a triangular tooth from Armagh, pl. lvii. f. 1 a group of 3 or 4 teeth from the black rock of the Avon Gorge, Clifton.

Tomodus convexus, L. Agassiz, MS., J. W. Davis, Scient. Trans. Roy. Dublin Soc. vol. i. ser. ii. p. 446, pl. lv. fs. 16, 18 [2 teeth]. Carb. Limest. (black rock), Avon Gorge, Clifton.

Cephalopoda.

Belemnites tubularis, Young and Bird, J. Phillips, British Belemnitidæ, Pal. Soc. p. 68, pl. xiv. f. 36, B. U. Lias, Loc. doubtful.

Note.—This specimen is said to be from near Gloucester, but there is little reason to doubt that it is a Yorkshire specimen from the neighbourhood of Whitby, vide Phillips, loc. cit.

Gasteropoda.

Alaria (Pterocera) Lorieri, A. d'Orbigny, *var. A.*, W. H. Hudleston, Pal. Soc. Inf. Ool. Gast. pt. i. p. 133, pl. vi. f. 6*d*. Inf. Ool. Dundry.

Alaria Lotharingica, Schlumberger, E. B. Tawney, Proc. Bristol Nat. Soc. n.s. vol. i. p. 22; W. H. Hudleston, Pal. Soc. Inf. Ool. Gast. pt. i. p. 125, pl. v. f. 9. Inf. Ool. Dundry.

Amberleya (Eucyclus) goniata, E. Deslongchamps, E. B. Tawney, Proc. Brist. Nat. Soc. N.S. vol. i. p. 28, pl. ii. f. 5. Inf. Ool. Dundry.

Amberleya (Turbo) "*ornata*," J. Sowerby, E. B. Tawney, Proc. Brist. Nat. Soc. N.S. vol. i. p. 27, pl. i. f. 9; "syn. of *Amberleya (Turbo) capitanea*, Münster." Inf. Ool. Dundry.

Dentalium medium, J. Sowerby, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 343, pl. xviii. f. 4. Up. Greensand, Blackdown.

Euspira (Natica) Bajocensis, A. d'Orbigny, E. B. Tawney, Proc. Brist. Nat. Soc. N.S. vol. i. p. 13, pl. i. fs. 2, 4. Inf. Ool. Dundry.

Euspira (Natica) Zelima ?, A. d'Orbigny, E. B. Tawney, Proc. Brist. Nat. Soc. N.S. vol. i. p. 14, pl. i. f. i. Inf. Ool. Dundry.

Pleurotomaria subreticulata, A. d'Orbigny, E. B. Tawney, Proc. Brist. Nat. Soc. N.S. vol. i. p. 46, pl. iii. f. 7. Inf. Ool. Dundry.

Purpurina Bellona, A. d'Orbigny, E. B. Tawney, Proc. Brist. Nat. Soc. N.S. vol. i. p. 11, pl. iii. f. 8. Inf. Ool. Dundry.

Rostellaria Parkinsoni, J. Sowerby, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 344, pl. xvii. f. 24; *Alaria*, F. Stoliczka, Cret. Gast. of S. India, p. 30. Up. Greensand, Blackdown.

Trochus Zetes, A. d'Orbigny, E. B. Tawney, Proc. Brist. Nat. Soc. N.S. vol. i. p. 32, pl. ii. f. 7. Inf. Ool. Dundry.

Pelecypoda.

Astarte sufflata, F. Römer, G. F. Whidborne, Q.J.G.S. vol. xxxix. p. 527, pl. xviii. fs. 15, 16 [double shell and left valve]. Inf. Ool. Dundry.

Cardinia concinna, J. Sowerby, S. Stutchbury, Ann. Mag. Nat. Hist. vol. viii. (1842) p. 485, pl. x. f. 13 [left valve with fragment of right valve]. L. Lias, Langar, Notts.

Cardinia Listeri, J. Sowerby, J. Stutchbury, Ann. Mag. Nat. Hist. vol. viii. (1842), p. 482, pl. ix. fs. 1, 2 [double shell and right valve]. L. Lias, Hewletts Hill, Cheltenham.

Lima semisulcata, Nilsson, J. de C. Sowerby (Fitton), Trans. Geol. Soc. ser. ii. vol. iv. p. 336, pl. xii. f. 10 [single valve ? left]. Up. Greensand, Blackdown.

Trigonia alæformis, J. Sowerby, Min. Conch. pl. 215, f. 3; syn. of *T. aliformis*, J. Parkinson, Organic Remains vol. iii. p. 176. Up. Greensand, Blackdown.

Brachiopoda.

Productus comoides, J. Sowerby; *Chonetes*, T. Davidson, Q.J.G.S. vol. x. p. 202, pl. viii. f. 1, and Brit. Foss. Brach. vol. ii. p. 180, pl. xlv. f. 7 [double shell]. Carb. Limest. Loc. doubtful.

Waldheimia ? (Terebratula) Anglica, A. Oppel, T. Davidson, Brit. Foss. Brach. Supplement to vol. i. p. 20, pl. a. fs. 10 ? 11-13, as var. of *T. sphæroidalis*, Sow.; *op. cit.* Supplement to vol. iv. p. 135, as *T. Anglica*, Oppel; *op. cit.* vol. v. p. 270, as *Waldheimia* [3 or 4 double shells as casts]. Inf. Ool. Dundry.

Note.—The specimens described by Davidson were stated by him to belong to the Bristol Museum, but it is not very clear that the specimens in this Museum so referred are the same.

Crinoidea.

Dichocrinus radiatus, Münster, T. and T. Austin, Mono. Crinoidea, p. 45, pl. v. f. 5 *c* [calyx]. Carb. Limest. ? Loc.
Platycrinus gigas, J. Phillips, T. and T. Austin, Mono. Crinoidea, p. 38, pl. iv. fs. 1*a*, *b*, *c* [calyx]. Carb. Limest. ? Loc.
Platycrinus rugosus, J. S. Miller, T. and T. Austin, Mono. Crinoidea, p. 40, pl. iv. fs. 2 *d—k*. Carb. Limest. ? Loc.
Poteriocrinus crassus, J. S. Miller, T. and T. Austin, Mono. Crinoidea, p. 69, pl. viii. f. 3 *c* [column and fragment of calyx]. Carb. Limest. Clevedon.
Synbathocrinus conicus, J. Phillips, T. and T. Austin, Mono. Crinoidea, p. 93, pl. ix. f. 5 [column, calyx and arms]. Carb. Limest. Hook Point, Wexford.

Actinozoa.

Alveolites (*Favosites*) *septosa*, J. Fleming, M. Edwards, and J. Haime, Brit. Foss. Corals, Pal. Soc. p. 157, pl. xlv. f. 5 [a subglobose mass]. Carb. Limest. ? Loc.
Clisiophyllum turbinatum, F. McCoy, M. Edwards and J. Haime, Brit. Foss. Corals, Pal. Soc. p. 184, pl. xxxiii. f. 1 [a short specimen]. Carb. Limest., Clifton.
Clisiophyllum coniseptum, A. Keyserling, M. Edwards and J. Haime, Brit. Foss. Corals, Pal. Soc. p. 185, p. xxxvii. f. 5 [a large specimen partly broken]. Carb. Limest. ? Loc.
Cyathophyllum regium, J. Phillips, M. Edwards and J. Haime, Brit. Foss. Corals, Pal. Soc. p. 180, pl. xxxii. f. 4 [two corallites issuing from the same parent]. Carb. Limest. ? Loc.
Michelinia (*Manon*) *favosa*, Goldfuss, M. Edwards and J. Haime, Brit. Foss. Corals, Pal. Soc. p. 154, pl. xliv. f. 2 [a large broken compound mass]. Carb. Limest. ? Masbury, Mendips.
Michelinia (*Calamopora*) *megastoma*, J. Phillips, M. Edwards and J. Haime, Brit. Foss. Corals, Pal. Soc. p. 156, pl. xliv. f. 3*b* [a polished oblique section]. Carb. Limest. ? Loc.
Michelinia (*Calamopora*) *tenuisepta*, J. Phillips, M. Edwards and J. Haime, Brit. Foss. Corals, Pal. Soc. p. 155, pl. xliv. f. 1 [a small mass]. Carb. Limest., Masbury, Mendips.

Plantæ.

Alethopteris Davreuxi, Brongniart, R. Kidston, Trans. Roy. Soc. Edinburgh, vol. xxxiii. (1888) pt. 2, p. 386, pl. xxiv. f. 1. Coal Measures, Camerton.
Caulopteris macrodiscus, Brongniart, R. Kidston, Trans. Roy. Soc. Edinburgh, vol. xxxiii. (1888) pt. 2, p. 393, pl. xxv. f. 1. Coal Measures, Coalpit Heath, Bristol.
Rhacophyllum Goldenbergii, Weiss, R. Kidston, Trans. Roy. Soc. Edinburgh, vol. xxxiii. (1888) pt. 2, p. 388, pl. xxvii. f. 2. Coal Measures, near Pucklechurch, Gloucestershire.
Zoophycos (*Cancellophycus*) *scoparius*, Thiollière, E. B. Tawney, Proc. Brist. Nat. Soc. ser. ii. vol. vii. (1873) pt. 2, pp. 40, 41. Inf. Ool., Rackledown Quarry, Dundry.

List of the Principal Works relating to Fossil "Types" and Described Specimens in the Bristol Museum.

1768. *A. Catcott*, A. Treatise on the Deluge, second ed.
1812-29. *J. Sowerby*, Mineral Conchology of Great Britain.
1821. *J. S. Miller*, A Natural History of the Crinoidea.
1823. *W. Buckland*, Reliquiæ Diluvianæ.
1829. *J. Cottle*, Malvern Hills, with Minor Poems and Essays. 8vo. Fourth ed. 1829, vol. ii.; and reprinted folio ed. with plates, n.d.
1829. *J. S. Miller*, Observations on Belemnites, Trans. Geol. Soc. 2nd series, vol. ii.
1833-43. *L. Agassiz*, Recherches sur les Poissons Fossiles.
1836. *W. H. Fitton*, Observations on some of the Strata between the Chalk and the Oxford Oolite in the South-east of England, Trans. Geol. Soc. 2nd series, vol. iv. with Appendix, Descriptive Notes respecting the Shells figured by *J. de C. Sowerby*.
1840. *H. Riley* and *S. Stutchbury*, A Description of various Fossil Remains of three distinct Saurian Animals recently discovered in the Magnesian Conglomerate near Bristol, Trans. Geol. Soc. 2nd ser. vol. v.; Proc. Geol. Soc. vol. iii.
1840. *R. Owen*, Report on British Fossil Reptiles, Brit. Assoc. Rep. for 1839.
1842. *S. Stutchbury*, On a new genus of Fossil Bivalve Shells, Ann. and Mag. Nat. Hist. vol. viii.

1843 (circa). *T. Austin* and *T. Austin, jun.*, A Monograph on Recent and Fossil Crinoidea.
1846. *S. Stutchbury*, Description of a new species of Plesiosaurus in the Museum of the Bristol Institution, Q.J.G.S. vol. ii.
1852. *H. M. Edwards* and *J. Haime*, A Monograph of the British Fossil Corals, Palæontographical Society.
1854. *J. Morris*, A Catalogue of British Fossils, second edition.
1854-84. *T. Davidson*, British Fossil Brachiopoda, Palæontographical Society, Suppl. to vol. i. vol. iv. and vol. v.
1855. *P. de M. G. Egerton*, Figures and Descriptions illustrative of British Organic Remains, Mem. Geol. Survey of the United Kingdom, dec. viii.
1857. *C. Gould*, Description of a new fossil Crustacean (*Tropifer lævis*, C. Gould) from the Lias Bone-bed, Q.J.G.S. vol. xiii. p. 360.
1865. *J. Phillips*, A Monograph of British Belemnitidæ, Palæontographical Society.
1868. *F. Stoliczka*, Cretaceous Fauna of Southern India, vol. ii. the Gastropoda, Mem. Geol. Surv India, Palæontologia Indica.
1868. *H. Falconer*, Palæontological Memoirs and Notes of the late, edited by Charles Murchison, vol. ii.
1870. *T. H. Huxley*, On the Classification of the Dinosauria, with Observations on the Dinosauria of the Trias, Q.J.G.S. vol. xxvi.
1871. *F. Stoliczka*, Cretaceous Fauna of Southern India, vol. iii. the Pelecypoda, Mem. Geol. Surv. India, Palæontologia Indica.
1874. *E. B. Tawney*, Museum Notes, "Dundry Gasteropoda," Proc. Bristol Nat. Soc. N. S. vol. i. part i.
1876. *J. S. Gardner*, Cretaceous Gasteropoda, Geol. Mag. Dec. II. Vol. III.
1877. *H. Woodward*, A Catalogue of British Fossil Crustacea in the British Museum.
1878. *L. C. Miall*, Monograph of the Sirenoid and Crossopterygian Ganoids, Palæont. Society.
1879. *W. J. Sollas*, On the Silurian District of Rhymney and Pen-y-lan, Q.J.G.S. vol. xxxv.
1881. *W. J. Sollas*, On a new species of Plesiosaurus (*P. Conybeari*) from the Lower Lias of Charmouth; with Observations on *P. megacephalus*, Stutch., and *P. brachycephalus*, Owen, with Supplement on the Geographical Distribution of the genus Plesiosaurus by *G. F. Whidborne*, Q.J.G.S. vol. xxxvii.
1882. *W. Downes*, The Zones of the Blackdown Beds and their Correlation with those at Haldon, with a List of their Fossils, Q.J.G.S. vol. xxxviii.
1883. *J. W. Davis*, Monograph on the Fossil Fishes of the Carboniferous Limestone Series of Great Britain, from the Scientific Transactions of the Royal Dublin Society, vol. i. series ii.
1883. *G. F. Whidborne*, Notes on some Fossils, chiefly Mollusca, from the Inferior Oolite, Q.J.G.S. vol. xxxix.
1886. *R. Lydekker*, Catalogue of the Fossil Mammalia in the British Museum, Parts iii. and iv.
1887-89 *et seq.* *W. H. Hudleston*, Inferior Oolite Gasteropoda, Nos. 1, 2, 3 *et seq.* Palæontographical Society.
1888. *R. Kidston*, On the Fossil Flora of the Radstock Series of the Somerset and Bristol Coal-field (Upper Coal Measures), Trans. Roy. Soc. Edinburgh, vol. xxxiii. pt. ii.
1888. *E. Wilson*, The Bone Cave or Fissure of Durdham Down, Proc. Bristol Naturalists' Soc. N. S. vol. v.
1888-89. *R. Lydekker*, Catalogue of the Fossil Reptilia and Amphibia in the British Museum, Part 1, Dinosauria, Part 2, Ichthyopterygia and Sauropterygia.
1889. *A. S. Woodward*, Catalogue of the Fossil Fishes in the British Museum, part 1, Elasmobranchii.
1890. *A. S. Woodward* and *C. D. Sherborn*, A Catalogue of British Fossil Vertebrata.

NOTICES OF MEMOIRS.

I.—Note on a Fossil Fish and Marine Worm found in the Pleistocene Nodules of Green's Creek on the Ottawa. By Sir J. William Dawson, F.R.S. (Canadian Record of Science, vol. iv. pp. 86–88, April, 1890.)

THE Pleistocene Clays of Green's Creek are well known from the occurrence in them of fish-bearing nodules resembling those found on the coast of Greenland. *Mallotus villosus*, *Osmerus mordax*, *Gasterosteus aculeatus*, and *Cyclopterus lumpus*, have already been recorded from this deposit; and Sir William Dawson now adds a species of *Cottus*, which seems to be *C. fasciatus* of Reinhardt. Other nodules containing Nereid worms are also described, and believed to represent a species of the genus *Nereis*.

II.—The Occurrence of Radiolaria in Albite Crystals.

A. Issel. Radiolaires fossiles contenues dans les cristaux d'albite. Compt. Rend. tome cx. pp. 420—424, Fevr. 24, 1890.

A. Issel. Il Calcifiro fossilifero di Rovegno in Val di Trebbia. Annali del Museo Civico di Storia Naturale di Genova, (2) ix. 1890, pp. 91—119, pls. v. and vi.

PROBABLY one of the last places in which a geologist would attempt to commence fossil collecting would be in a rock containing authigenous crystals of albite, and perhaps the most remarkable discovery announced in the present year is that not only does such a rock yield a Radiolarian fauna, but that the fossils occur in the albite crystals themselves. The calciphyre, in which this unexpected find has been made, occurs at several places round Rovegno, a village situated in the tongue of Pavia that runs south up the Trebbia valley to the summit of the Ligurian Apennines. The rock occurs in a series of calcareous marls, calcareous and argillaceous "schists" and tiles, belonging to the group of Upper Eocene beds (piano liguriano), which has already yielded so many interesting results. The beds are so much contorted that the stratigraphical sequence is determinable but with difficulty; the fossiliferous rock, however, certainly belongs to the lower part of the series, the upper part of which consists of serpentines, gabbro, diabase, phtanite with pyrolusite, and breccias. The calciphyre occurs intercalated with beds of hard, black, siliceous schist, which together are 6·3 mètres in thickness; the limestone is of a groundmass of ordinary cryptocrystalline calcite, in which are scattered crystals of felspar; these are often minute in size, but range to a length of 3 cm. Their crystallographic and optical properties clearly prove them to be albite. Analyses of the rock and of the insoluble residues are given; these, however, are less satisfactory; thus in the former 10 per cent. of silica is accompanied by only traces of alkalies; hence so much other siliceous matter must be present that little can be learnt from bulk analyses. The Radiolaria occur mostly within the albite, but sometimes a specimen projects above the face of a crystal into the surrounding matrix. That the structures really are Radiolaria there seems little room for doubt. Prof. Issel has had considerable experience in the examination of the Radiolarian fauna of the diaspores that occur in the same series;[1] while the plate of microphotographs that accompanies the second

[1] See, *e.g.* his recent paper, "Dei noduli a radiolarie di Cassagna e delle roccie silicee e manganesifere chi vi si connettono," Atti Soc. Ligus. Sci. Nat. e Geogr. vol. i. No. 1, 1890.

paper seems quite sufficient to settle the question. The fossils are referred to the genera *Ethmosphæra*, *Heliosphæra*, *Caryosphæra*, *Lithopera*, *Spirocampe*, *Dictyomitra*, *Euchitonia*, *Stichocampsa*, and *Polystichia*; *Microlecitos* is a new genus. Moreover, there seems to be no doubt that the albite has been formed *in situ* around the Radiolaria, the material in the chambers of which is often different from that of the albite around it; a halo of less transparent matter also often surrounds the test of the fossil. The limestone shows signs of erosion by acidulated water, and Issel attributes the formation of the calciphyre to hydrothermal agencies acting upon a calcareous marl at or subsequent to the emission of the overlying "anfimorphic" rocks. Hence he concludes "that from this we see that the formation of large crystals of felspar in the heart of a sedimentary rock may be a local phenomenon produced independent of the cause to which metamorphism is by many attributed." J. W. G.

III.—"*Ichthyosaurus campylodon* E TRONCHI DI CICADEE NELLE ARGILLE SCAGLIOSE DELL' EMILIA." By Prof. G. CAPELLINI. [Mem. R. Accad. Sci. Istit. Bologna, ser. 4, vol. x. (1890), pp. 1-24, pls. i. ii.]

IN the Bulletin of the Italian Geological Society last year (vol. viii. pp. 43–45), Prof. D. Pantanelli announced the discovery of Saurian jaws in the supposed Eocene beds of Emilia, determining them to be Crocodilian, and applying to them the name of *Gavialis mutinensis*. Prof. Capellini now gives good figures and a detailed description of the fossil in question, proving that it is a fragment of the snout of *Ichthyosaurus campylodon,* and must have been derived from the Cretaceous formation. The Professor is also engaged at present, in collaboration with Prof. Solms Laubach, upon a monograph of the fossil Cycads of Emilia: he thus adds a description and figure of a Cycadean stem from the same horizon as the Ichthyosaurus snout, proposing for it the name of *Raumeria masseiana*.

REVIEWS.

I.—THE CONNEXIONS OF THE ANIMAL WORLD IN GEOLOGICAL TIMES.

LES ENCHAINEMENTS DU MONDE ANIMAL DANS LES TEMPS GEOLOGIQUES—FOSSILES SECONDAIRES. By ALBERT GAUDRY. pp. 523, and 403 Woodcuts. (Paris, 1890.)

WITH this volume we have the third, and we presume the final, part of Prof. Gaudry's 'Enchainements'; and its appearance would seem to indicate that the work as a whole has been a financial success. If such a work were published in this country, we confess we should be rather at a loss to indicate the class of readers to whom it would be acceptable, since it makes no pretence to be a scientific and detailed palæontological manual, and yet appears to be too descriptive and technical for the ordinary reader desirous of obtaining a smattering of science. It is, however, quite probable that France may have a class of readers unrepresented among ourselves.

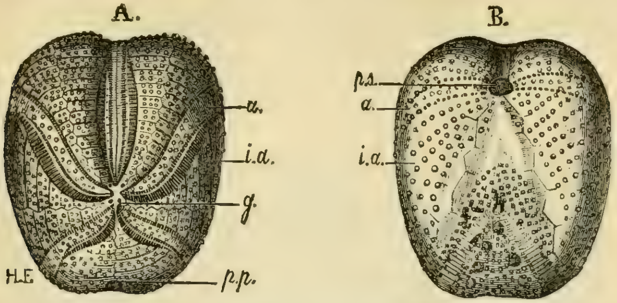

FIG. 1.—Upper (A) and lower (B) surfaces of the test of *Heteraster oblongus*; from the Neocomian.

The great feature of this, as of the preceding volumes, is the beauty and number of the illustrations, all of which are by M. Formant, whose name alone is sufficient guarantee for their excellence. By the courtesy of the author we are enabled to give specimens of these illustrations taken from various classes of the animal kingdom, so that our readers may judge for themselves.

The introductory chapter gives a valuable table of the various horizons of the Mesozoic rocks of France. The second chapter is devoted to the Foraminifera, the third to the Corals, and the fourth

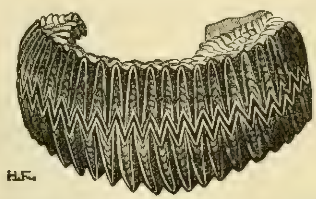

FIG. 2.—Shell of *Ostrea macroptera*; from the Neocomian.

to the Echinoderms. We notice that in the latter group not only is the minute structure of the test and of the 'lanthorn' very fully illustrated, but figures are given of nearly all the main types of form found in the test of the Urchins; we select *Heteraster* (Fig. 1) as a sample of the illustrations in this chapter. The Molluscs, as their importance deserves, have a long chapter to themselves, which is very fully illustrated. Fig. 2, taken from this chapter, strikes us as a first-rate example of wood-engraving. We notice that in the *Ostreidæ* the author regards *Gryphæa* merely as a subgenus of *Ostrea*, and certainly the series of figures given on page 77 goes far to support this view. In the Gasteropoda it is curious to note how *Malaptera* (fig. 60), of the Corallian, seems to be a more specialized type derived from the Oxfordian *Pteroceras* (fig. 156) by the 'webbing' of the spaces between the 'fingers.' In the Ammonites the author adopts as genera the numerous terms which have been proposed of late years, and figures several specimens (figs. 190, 191) exhibiting the rare feature of the complete mouth. The figures of the various modifications of the sutures of the lobes given on pp. 114, 115, will be found interesting and instructive.

Passing by the sixth chapter, which is devoted to the Brachiopods and Arthropods, we commence the Vertebrates with the seventh chapter; these occupying the remainder of the volume. In the

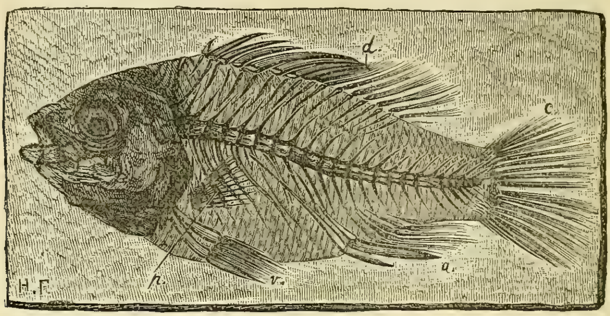

Fig. 3.—Skeleton of *Lates Heberti;* from the Pisolite of Mt. Aimé. $\frac{4}{5}$ nat. size.

chapter on Fishes the author traces the gradual tendency to a loss of a bony scale-armour as we advance in geologic time, and likewise the gradual increase in the degree of ossification of the endo-skeleton. We have selected the figure of the skeleton of *Lates* (Fig. 3), and of the jaw of *Mesodon* (Fig. 4) as good specimens of the illustrations in this chapter.

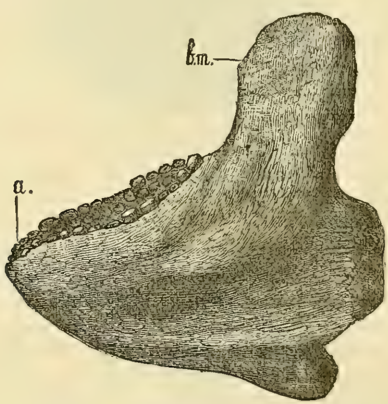

Fig. 4.—Outer side of the left ramus of the mandible of *Mesodon profusidens*; from the Neocomian. $\frac{3}{4}$.

Under the heading Reptiles the author includes both the animals properly so called and also the Amphibians. In treating of the Labyrinthodonts, the Professor expresses strong doubts whether the footprints described as *Chirotherium* are really due to members of this group, and inclines to the view that they were more probably made by Dinosaurs. We venture to think that the interesting group of Anomodonts (including the Theriodonts) are dismissed with too brief a notice on pp. 178-179. In the Ichthyosauria we note with interest another example (fig. 275) showing a fœtus *in ventre*; the specimen does not, however, belong to *Ichthyosaurus tenuirostris*, and should apparently be referred to *I. acutirostris*. In comparing (p. 194) the structure of the limbs of *Ichthyosaurus* and *Pliosaurus*, we must totally differ from the suggestion that there can be any possible genetic relationship between the two genera, the former having evidently descended directly from forms allied to *Plesiosaurus*, with which *Ichthyosaurus* has no sort of connexion. Good figures of the skulls of *Nothosaurus* and its allies are given on page 196, one of which we reproduce in Fig. 5. We observe that the author leaves

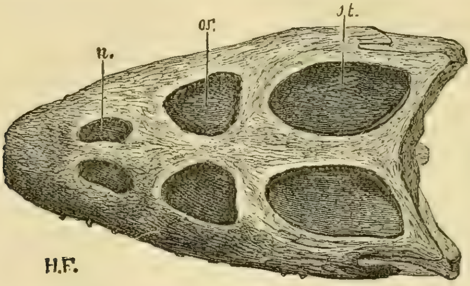

Fig. 5.—Upper surface of the skull of *Simosaurus Guillielmi*; from the Muschelkalk. *n.* nares; *or.* orbit; *st.* supratemporal fossa. $\frac{1}{4}$ nat. size.

Placodus and *Cyamodus* in the neighbourhood of *Simosaurus*, somewhat naively confessing (p. 190) that he does not know what an Anomodont or a Theriodont really is; and thereby, in regard to the latter group, merely repeating a similar confession made by a learned English palæontologist in 1880.[1]

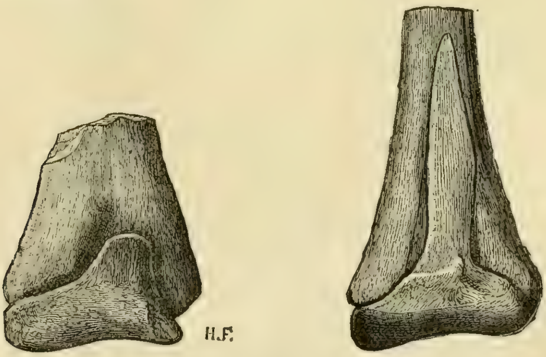

Fig. 6.—Anterior surface of the distal end of the tibia and astragalus of *Megalosaurus* and a young Ostrich. Reduced.

[1] Quart. Journ. Geol. Soc. vol. xxxvi. p. 543.

In the section on the Dinosaurs the figure of the tibia and astragalus of *Megalosaurus*, which we reproduce in Fig. 6, shows very clearly the close resemblance presented by the mutual relationship of these bones to those of the young Ostrich. Why, however, the author should have gone out of his way to suggest that in both these instances the astragalus is but an epiphysis of the tibia we are somewhat at a loss to understand. In the same group the figures of the bones of *Dimodosaurus*—a Dinosaur hitherto unknown to us —are of interest as showing the apparently close relationship of that form to *Thecodontosaurus* and *Anchisaurus*. Judging, however, from Prof. Marsh's figures of the hind foot of the latter, there is some error in the restoration of the foot of *Dimodosaurus* given on p. 219 of the work before us.

Space does not permit of a detailed notice of the remaining portion of the text devoted to the other Reptiles, nor of the chapters on *Archæopteryx* and the Mesozoic Mammals. We cannot, however, pass without notice the comparison on pp. 244, 245, between Pterodactyles and Bats; and the suggestion, however guarded, of any affinity between the two. Here the author does not seem to know his own mind; either Pterodactyles or Bats are or are not connected; if they are, well and good; but if they are not, we fail to see how the former can in any sort of way lessen the interval dividing Mammals from Reptiles.

We offer our congratulations to the Professor on having at length reached the end of the long task he has set before himself. R. L.

II.—The Life and Letters of the Reverend Adam Sedgwick, LL.D., D.C.L., F.R.S., etc. By J. W. Clark, M.A., F.S.A., and T. McKenny Hughes, M.A., F.R.S., etc. Two vols. 8vo. pp. 539, 640; with Portraits, Maps, and other Illustrations. (Cambridge, at the University Press, 1890.)

IT is well that the Biography of Adam Sedgwick has been published, for no one can read the record of his life without feeling the better for it. Seventeen years have passed since the "First of Men" (as Sedgwick was known among his scientific associates) passed away from earthly scenes; and there is indeed some reason to regret that the work was not sooner published. Intimate friends of Sedgwick have lamented the delay, and geologists who are more or less interested in the Cambro-Silurian controversy, have wished for a fuller account of the circumstances which for a number of years obscured much of the great work done by Sedgwick. His claims, however, to a foremost place among the founders of our science have not been questioned; his particular work now-a-days receives adequate acknowledgment; and as the years roll by there is a growing disposition to deal amicably with the vexed subject of Palæozoic nomenclature.

So far as the Biography of Sedgwick is concerned, we question if the delay has been at all prejudicial. Prof. Hughes, who originally took in hand the task, found himself unable to devote the necessary time to the work, and fortunately secured the skilled help of Mr. Clark, to whom we owe the greater portion of the two volumes. Thus, more ample justice has been done to the life and times of Sedgwick, than could have been the case with a less exhaustive collection and consideration of the materials; and there are many who hold that the life of a man should not be published until at least twenty-five years after his death.

Not geologists alone, but all to whom biography has attraction, will welcome these volumes, bringing before us as they do the chief incidents in the life of "a Master among Philosophers" and "a singularly genial and loveable man." The accounts which Sedgwick himself has given of the manners and customs of the people of Dent, where he was born in 1785, form one of the most attractive portions of the first volume. To this Yorkshire village he returned again and again in after-life, ever regarding it with affection. In old times "there was kept alive a feeling of fraternal equality" among the several classes of inhabitants; and while there still lived some who had known Sedgwick in his youth, he never visited Dent without hearing his Christian name uttered by the dalesmen.

One of his early employments on a half-holiday during the period he attended the Grammar School at Dent, was to collect the conspicuous fossils of the Mountain Limestone of his native valley. While, however, these rambles aided to establish a taste for out-door observations, it was many years before Sedgwick gave any systematic attention to geology. Proceeding to Cambridge in 1804, he entered Trinity College, and was admitted to the Degree of Bachelor of Arts in 1808, when his name stood fifth in the first class, or Wranglers. We may pass briefly over his early college experiences, but it is important to mention that he overworked himself in preparing for his Fellowship examination, and the chronic ill-health from which he suffered during the rest of his life may be traced to the strain he endured during this period. For several years he was occupied as Private Tutor and afterwards as Assistant Mathematical Tutor at Trinity College.

His wish had been to read for the Bar, but as it became necessary to create an independence for himself as soon as possible, he was led to enter the Church, for which, at the time, he had no very decided inclination. Indeed, his resolution to read divinity was not at first carried out with much vigour, for it appears that in the following vacation Boswell's Life of Johnson was the only book that occupied his attention. His work, however, at this time, whether mathematical or theological, did not arouse his enthusiasm; he felt his life to be one of rather dull uniformity, while his health unfitted him, now and in after-life, for long continued sedentary labour. During holiday excursions in 1813 we find him visiting the iron-mines of Furness and the copper-mines near Coniston; but two years later, at Dent, geology had not gained his affections, for he was constantly out on the moors, where he "killed a good many birds." In 1817 he was ordained Deacon, and in the following year he was admitted to Priest's Orders.

Now came the crisis of his life. Sedgwick was thirty-three years of age, when it was announced that the Rev. John Hailstone, who had been Woodwardian Professor of Geology since 1788, was proposing to vacate the office. Sedgwick had no special claims to justify him in becoming a candidate; he desired a motive for active exertion in a way that would promote his intellectual improvement. He was opposed by Gorham (subsequently of controversial fame), but Sedgwick, who was supported, as a man of talent, by his College, polled 186 votes against 59 of his rival. Sedgwick remarked, "Hitherto I have never turned a stone; henceforth I will leave no stone unturned," and the energy and enthusiasm with which he set to work is well told in these pages. His earliest lessons were taken alone in the field, with the maps of William Smith in his hand, when he traversed on foot the Cretaceous and Oolitic rocks of Wiltshire and Somersetshire. To quote from the volume before us, "He always contrived to combine a large amount of amusement with business. 'That lively gentleman Mr. Sedgwick,' as he was called by a stranger who met him in a stage-coach, had a happy knack of making himself agreeable to everybody with whom he happened to be brought into contact, and his geological tours gave him a wide and varied experience of mankind. With all sorts and conditions of men, quarrymen, miners, fishermen, smugglers, shepherds, artisans, grooms, inn-keepers, clergy of all denominations, squires, noblemen—he was equally communicative, and soon became equally popular. He could make the most silent talk, and could extract information and amusement out of materials that seemed at first sight destitute of either quality."

We are told how he made acquaintance with J. J. Conybeare, and afterwards with his more distinguishished brother W. D. Conybeare, whom Sedgwick came to regard as his Master in Geology. As early as 1819 he began to make original observations, and between that date and 1827 he explored much of the West of England, Yorkshire, Durham, and the Lake District. Accounts of his journeys are communicated in letters; and indeed throughout his life, Sedgwick was a capital letter-writer. The records of these early investigations are especially interesting, for Sedgwick explored the districts for the most part on foot, carrying heavy burdens of rocks and fossils, and finding shelter after the labours of the day at one of the country inns. Occasionally we find him accompanied by Henslow or Whewell; but his chief work in early years was done alone. When at Cambridge, "He was probably the most popular man in the college, and his rooms the chief centre of attraction. Intimate friends were glad, when their own work was over, to enjoy his original conversation, and not seldom his extravagant fun. . . . Of the leading men in Cambridge sixty years ago, no one made so lasting or so favourable an impression on all who were brought into contact with him as Sedgwick."

We must, however, pass rapidly over the many interesting topics that are brought forward in these volumes. Throughout his life much of Sedgwick's time was occupied in matters relating to his College or the University; he became Vice-Master of Trinity College, and Secretary to the Chancellor (Prince Albert); and he took a prominent part in election contests. His geological work shows how "by steady application a man of talent may be able to make observations of the first order in the field two years after commencing the study of the subject." He was, however, slow to publish the results of his labours, and sometimes four or five years elapsed before his observations were worked out. His acquaintance with Murchison commenced in 1827, and the two friends were soon journeying together to the Highlands, and ultimately to parts of Wales and Devonshire. If it is regretted that Sedgwick never married, and indeed refused, in 1832, a comfortable living in the south of England, it may be questioned if he would have done more for science (as Lyell suggested), for he could not then have continued his long and arduous excursions. His friend Conybeare writes in 1828: "I shall not be very efficient in the field, for I have not, from the demands of a large family, either time or funds for much touring."

Particular accounts of Sedgwick's work in Wales are given, with facsimiles of some of his MS. sections; and when he had practically completed his explorations in 1846, at the age of 61, he says he had the precise general views he had at the end of 1832, of course with infinitely improved details and better sections. It was not, however, till 1852 that matters were entirely cleared up, when the Caradoc Sandstone, which had been the main source of difficulty and confusion, was clearly separated from the May Hill Sandstone by Sedgwick, with the aid of M'Coy. The unfortunate association of these strata by Murchison was doubtless the cause of the Cambro-Silurian troubles, and Murchison admits that it was not he "who *made Cambrian into Lower Silurian*, but the Government surveyors and palæontologists." Sedgwick's views, too, became misinterpreted, owing to unauthorized alterations in one of his papers published by the Geological Society, so that De la Beche was led to remark to him, "Sedgwick, you have given up a very good nomenclature!"

Geologists now in the Biographies of Sedgwick and Murchison have ample material in which to read the history of the great work done by these old masters. In his latest work, Sedgwick thus speaks of the "Silurian System" of his comrade:—"But the chief honour will ever be given to the author of the System, who brought the materials together and arranged them in that manner in which they are seen in his splendid work. Under his hands the older Palæozoic Geology had assumed a new and nobler type." These generous words, penned by Sedgwick the year before he died, urge us to deal in the same spirit with the respective claims of Sedgwick and Murchison to fix the nomenclature of our older Palæozoic rocks. The order of succession is not in dispute. The claims of science stand before purely personal matters. A threefold division of these rocks has been found most convenient, so that the new term Ordovician, proposed in place of the Upper Cambrian of the one author and the Lower Silurian of the other, has been widely adopted. By its use students at once understand the series of strata it implies, and if it fails to satisfy the particular advocates of Sedgwick and Murchison, this itself is an indication that justice has been done.

Sedgwick's whole life was dominated by an intention to write a general work upon the Palæozoic rocks of this country. His health, however, and his many engagements prevented his giving sufficient energy and time to the accomplishment of this particular work. The second volume of his Biography is largely occupied with his life at Norwich, at which place he resided for a portion of each year from 1834, when he was appointed to a Prebendal Stall in the Cathedral. The life in the old city was congenial, and as a friend writes, "Under his roof we learnt the true meaning of the word 'hospitality.'" Canon Robinson contributes a chapter dealing with the life at Norwich which is full of interest. Some of Sedgwick's stories are there narrated, including the account of "The Lady and the Shilling." This is given as happening in Wales. In Caroline Fox's "Memories of Old Friends" (Ed. 2, 1882, vol. i. p. 70) the incident is mentioned, as happening to Sedgwick when walking from Falmouth to Truro; and Miss James, an eccentric lady, is stated to have given him the shilling, and to have met him at dinner the same evening.

The volumes contain several touching and amusing anecdotes, as well as reminiscences of famous men and women, of Wordsworth, Jenny Lind, Livingstone, and many others, and accounts of visits paid to the Queen and Prince Albert. There is a history of the old Woodwardian Professors, and a portrait and biography of John Woodward: but we must refer our readers to the volumes for accounts of these and many other interesting matters which space would not allow of our mentioning.[1]

III.—The Geological Features of the North Staffordshire Coal-Fields, their Organic Remains, their Range and Distribution; with a Catalogue of the Fossils of the Carboniferous System of North Staffordshire." By John Ward, F.G.S. [Trans. N. Staffs. Inst. Mining and Mechan. Engineers, vol. x. 1890, pp. 1–189, pls. i.–ix.]

FOR the last thirty years the author of the present volume has been engaged in investigating the stratigraphy and palæontology of the North Staffordshire Coal-fields. During the progress of the Geological Survey of the area in question, Mr. Ward rendered much aid in matters which none but a constant observer upon the spot could satisfactorily elucidate; and for many years his unique collection of Coal-measure Fishes has formed the basis of important memoirs by the late Sir Philip Egerton, Prof. John Young, and Dr. R. H. Traquair. The whole of the collecting has been carried on systematically, each fossil being marked with the name of the

[1] A short biography of Sedgwick, accompanied by a portrait, and list of his principal papers, was printed in the Geol. Mag. for April, 1870, p. 145. The year of his birth is there given as 1784; it should be 1785.

precise stratum from which it was obtained; and while most groups of organisms occurring in the British Coal-measures are well represented, the fish-remains are especially valuable as displaying so many anatomical details that are rarely shown in other collections.

A general summary of the results of such patient investigations is always welcome; and the work before us has the appearance of no hurried sketch, but of a fully matured series of conclusions. The Stratigraphical Section occupies half the volume and embodies the author's personal observations; while in the Palæontological Section the assistance of several well-known specialists has been secured, Mr. R. Kidston having determined the plants, Mr. R. Etheridge having described and determined many of the invertebrate fossils, while most of the novelties among the Ganoid fishes are treated by Dr. R. H. Traquair.

The district described is bounded on the eastern margin by the Carboniferous Limestone of Derbyshire, on the southern and western margins by the Lower Permian and Triassic formations; and some preliminary remarks are offered on the surrounding Lower Carboniferous and Permian deposits before entering upon the proper subject of the work. Four distinct basins are recognized:—the Pottery Coal-field, that of Wetley and Shafferlong, that of Goldsitch Moss, and that of Cheadle. Each of these is described in detail, with numerous pit-sections and lists of fossils, almost all of which are now for the first time published. The total vertical thickness of the coal- and ironstone-bearing strata in the Pottery Coal-field is about 3951 feet; the Wetley and Shafferlong Coal-field is comparatively insignificant; the corresponding measures of Goldsitch Moss are not of much commercial value, and probably do not exceed 700 feet in thickness; while the Cheadle Coal-field is also small, though comprising twelve workable seams of coal of an aggregate thickness of over 40 feet, besides a valuable bed of hæmatite which is mined at the base of the series. All the more important horizons are described with their local names; and an attempt is made to divide the measures of each Coal-field into an Upper, Middle, and Lower group. For the most part these details will be appreciated by the mining engineer rather than by the ordinary geologist; but the interest of the latter is sustained by the series of lists of the fauna and flora, which indicate the various changes in physical conditions during the deposition of the successive beds.

The "Catalogue of Organic Remains" is systematically arranged, the principal literature-references, besides localities and horizons, being appended to each species from the Coal-Measures. Among the Mollusca, two new species, *Anthracomya Wardi* and *Sanguinolites granulatus*, are described by Mr. Etheridge, and the last mentioned is also figured. On the same plate several other Molluscs of the genera *Anthracosia*, *Anthracomya*, *Modiola* and *Goniatites*, are likewise well illustrated, in addition to species of *Discina*, *Chonetes*, and *Lingula*, and part of the spiny Myriapod, *Euphoberia*. More detailed notices of the Fishes and Amphibia are given, and these form the subject of no less than eight plates, of which one is large and folded. Among Elasmobranch Fishes, *Orthacanthus* is retained as a genus distinct from *Pleuracanthus*; a new form of tooth is named *Diplodus equilateralis*; and a specimen of *Ctenoptychius apicalis* is described as showing minute dermal tubercles, but no fin-spines. *Ctenodus Murchisoni* is briefly described for the first time; and *Dendroptychius* is relegated to the synonymy of *Strepsodus sauroides*. A description of *Megalichthys pygmæus*, sp. nov., is contributed by Dr. Traquair, with figures; and to the same ichthyologist, or to Mrs. Traquair, are due several drawings of Palæoniscid and Platysomid Fishes, notably those of *Elonichthys microlepidotus*, *Gonatodus Molyneuxi*, *Rhadinichthys Wardi* and *Platysomus parvulus*, all of which appear for the first time. Brief notes on the Labyrinthodonts conclude the catalogue, and these are illustrated by figures of *Keraterpeton Galvani*, and a mandibular ramus of *Loxomma Allmani*.

The North Staffordshire Institute and their publishers are to be congratulated on the excellent style in which this volume is issued; and it is to be hoped that at least the palæontological aspect of the subject will be still further treated by Mr. Ward in more special publications. A. S. W.

IV.—Wisnioski, Thaddeus. Mikrofauna iłów ornatowych okolicy Krakowa. Część 1. Otwornice górnego Kellowayu w Grojcu. [Foraminifera of the Kelloways Beds of Grojce.] *Pamietnik Ak. Umiej. Krakowie*, vol. xvii. 3 plates. (1890.)

The author describes the rich foraminiferal fauna of the Kelloways beds (Callovian) of Grojce. These marls, about six feet thick, are on the horizon of *Cosmoceras ornatum* (Schloth.), and we are already indebted to M. Teisseyre for a description of the Cephalopoda found therein. The author notes 124 "species" of Foraminifera, 60 of which he unfortunately sets down as "new." With most of these determinations we are forced to disagree; and cannot help feeling that many of them might have been correlated with forms previously described, the well-known variation in the test of these simple animals having been shown to have but little specific or even generic value by Parker and Jones, Brady, Goës, and other authors, who, from a long and careful study of the recent forms, have contributed so much to the reduction of the "species" of earlier authors. We regret, therefore, that recent writers, who have not the same advantage of studying fine collections from present-day deposits, do not hesitate to name as specific the smallest individual variations. Thus figs. 29 to 36 of pl. ii. (ix.) in M. Wisnioski's paper cannot be referred to more than one and the same "species," the variation being merely individual; and the same may be said of figs. 7 to 16 and 18 to 20 of the same plate. Fig. 28 of plate iii. (x.) is a true Cristellarian, as evidenced by the characteristic mouth shown in fig. *b.*; figs. 1, 3, 4, 5, and 11 of pl. iii. (x.) also all belong to one "species"; and it is difficult to imagine how the author arrives at the conclusion that he is here dealing with distinct species. We are much indebted to M. Wisnioski for figuring these

Jurassic Foraminifera; but have felt bound to call attention to such unnecessary multiplication of specific names in a group already so largely complicated by this faulty treatment. We do not now name as new every slight variation of hair or feathers in the Vertebrata; and the surface-markings and shape of the Foraminifera are almost exactly parallel in value. A brief abstract in French will be found in the *Bull. Ac. Sci. Cracovie*, for February, 1890. C. D. S.

V.—On some Australian Species of the Family Archæocyathinæ. By R. Etheridge, jun., Palæontologist to the Australian Museum and Geological Survey of N. S. Wales. Transactions of the Royal Society of South Australia, 1890, pp. 10–22, pls. ii. iii.

HITHERTO the fossils belonging to this family have only been definitely known from the Cambrian strata of Labrador, New York State, Nevada, Spain, and Sardinia, although some badly-preserved specimens from supposed Devonian rocks of New South Wales were referred many years since by Prof. De Koninck to the genus *Archæocyathus*. These fossils have unfortunately since been destroyed by fire, so that their real nature must remain undetermined; but if they were correctly referred to the above genus, the rocks from whence they come are probably much older than the Devonian period. That forms closely allied to *Archæocyathus* do, however, occur in Australian rocks, is very conclusively shown in the present paper, which contains descriptions of new species of *Ethmophyllum*, *Coscinocyathus* and *Protopharetra*, hardly to be distinguished from the typical forms of these genera in the rocks of North America and Sardinia. The Australian fossils are from limestone strata at Ardrossan, Yorke's Peninsula, Kanyka, north-east of Porth Augusta, and some other localities in the Flinders Range still further to the north;—all in the colony of South Australia. The specimens are for the most part imbedded in the hard rock, and can therefore only be studied in sections; not only in form but also in mineral structure they show a close similarity to specimens from Sardinia and North America, and this resemblance is not limited to the fossils merely, but includes the matrix as well, so that hand-specimens of the *Archæocyathus* limestones from Yorke's Peninsula could scarcely be separated from pieces of rock similarly filled with these organisms, from the Labrador coast or from Sardinia.

Owing to the way in which the fossils are preserved, it is very difficult to ascertain specific details, and Mr. Etheridge has acted wisely in not increasing the number of species on necessarily imperfect data; but it is probable, considering the great number of specimens in the rock, that further forms will yet be made out. The geological horizon of these Australian *Archæocyathus* limestones —or at all events those from Yorke's Peninsula—has already been determined by the presence in them of Trilobites referred by Dr. H. Woodward to the genera *Dolichometopus* and *Conocephalites* and allied to species from the Potsdam strata of New York (Geol. Mag. 1884, pp. 342–344), and the correctness of this reference is now confirmed by the occurrence of the Archæocyathinæ, which are likewise associated with similar Cambrian Trilobites in New York and Canada. In Dr. Woodward's paper the relationship of the *Archæocyathus* forms was not recognized, but they were supposed to be Corals.

Mr. Etheridge further describes some peculiar microscopic tubuli, referring them doubtfully to *Girvanella.* Similar forms have been noticed by Dr. Bornemann in the Cambrian strata of Sardinia.

This paper is an important contribution to Australian geology, as it definitely proves the existence in that continent of a well-marked horizon of Cambrian rocks closely corresponding to the Lower Cambrian of the Northern Hemisphere.

CORRESPONDENCE.

WIND WAVES AND TIDAL CURRENTS.

Sir,—Mr. T. Mellard Reade, in putting before the readers of the Geological Magazine his views on the origin of the Lower Trias (Geol. Mag. Feb. April, and June, 1890) drew from Mr. Arthur R. Hunt, F.L.S., a letter on "Tidal Action," in which the latter denies the power of tidal currents to do the work invoked by Mr. Reade in his theory of the *marine* origin of the pebbles of the Bunter.

Mr. Hunt writes (Geol. Mag. April, 1890, p. 191) as follows: "It may be well to point out one line of evidence which seems to have been overlooked by the supporters of the tidal theory, *i.e.* the zoological." He gives the English Channel as an excellent test case, and remarks, that "if unchecked tidal currents are anywhere resistless, they should be so here. Do these tidal currents disturb the gravel, or sand, or even the mud on the Channel bottom? The marine fauna of the district answers this question with an emphatic negative." And again, "The presence of this Molluscan fauna in these very exposed localities is good proof that unchecked tidal currents sweeping over a fairly level sea-bottom are incapable by their own unassisted efforts of raising the sand."

Now without entering into the discussion of the main question raised by Mr. Reade, I beg to offer the following observations on the line of evidence suggested by Mr. Hunt, viz. the power of wind waves and tidal currents to disturb the sand or mud of the sea-bottom. To this end, I quote the *practical* experience of a well-known French marine zoologist, M. Hermann Fol, of the zoological laboratory at Nice, who in his yacht "Amphiaster," was, last year, entrusted with a mission by the French Minister of Public Instruction, to explore, from a zoological point of view, the littoral of Corsica and Tunis.

M. Fol is in the frequent habit of donning the diver's dress and descending to depths of from 30 to 100 feet and upwards in search of marine organisms. Quoting from a recent paper (Rev. Sci. June 7th, 1890) M. Fol says, "When there is a swell on the water, the task of the diver becomes very difficult. He is constantly tossed about in spite of himself and an irresistible force makes him oscillate like a pendulum.

This see-saw motion of the water, which is the counterpart of the swell on the surface, is felt nearly as much at 30 mètres (99 feet) as at 10 mètres of depth.

It cannot be attributed to the surf, due to the vicinity of the coast, since the fishermen who use trawl or drag net upon extensive banks, situated quite out at sea, know that after a storm, these banks at 50 ms. (164 feet) *and more, below the level of the sea, are completely swept clear of their usual inhabitants.*"

If, then, the movement of the water, as described by M. Fol, is felt at such depths in the Mediterranean Sea, how much more powerful must be the storms or currents of the English Channel to disturb gravel or sand, or temporarily displace the marine fauna? The fact that Molluscs still exist in an area swept by occasional storms and open to currents generated by tidal waves seems scarcely to warrant Mr. Hunt's assumption that tidal action has no influence whatever on the sea-bottom. MARK STIRRUP.

BOWDON, CHESHIRE.

OBITUARY.

WILLIAM KITCHEN PARKER, F.R.S.

BORN JUNE 23, 1823; DIED JULY 3, 1890.

THE late and deeply lamented Professor William Kitchen Parker, F.R.S., F.L.S., F.R.M.S., etc., was born June 23, 1823, and died suddenly July 3, 1890. He was a Biologist in the widest sense of the term, having systematically studied all grades of living organisms in both the Vegetable and the Animal World. His life throughout, from boyhood onward, was largely devoted to the study of the bony structure of Vertebrates, but botanical research in early days, and a wide examination of rhizopodal organisms, were rival pursuits, until his energies, well and bravely continued through ill-health, were more especially given to the elucidation of embryonic morphology, or the developmental growth of the skull and other parts of the Vertebrate skeleton. The results of this long-continued and enlightened study gave him a world-wide reputation; and his lines of research in this pursuit, grounded on the work already done by Rathke, Gegenbauer, and Huxley, have led to a great advancement in Biology, both for professors and students.

Geologists are indebted to Professor W. K. Parker's knowledge of Osteology for thoughtful notes on the Archæopteryx (GEOL. MAG. 1864, pp. 55–57), and on Fossil Birds from the Zebbug Cave in Malta (Proceed. Zool. Soc. 1865, and Trans. Zool. Soc. 1869); and his perfect acquaintance with Rhizopoda was shown in the treatment of several series of fossil Foraminifera, in joint papers with others. His rhizopodal studies were taking shape in 1856 (and probably before), when, examining fresh marine material from Bognor, and much larger supplies from Sponge-sands, and from among East-

Indian shells, he collected, mounted, and carefully drew a vast series of Foraminifera and other Microzoa. By the friendly advice of Professors W. Crawford Williamson and T. Rupert Jones, he then systematically treated the Foraminifera as a special study. One of the first results was his paper "On the Miliolitidæ of the East-Indian Seas" (Trans. Microsc. Soc. n.s. vol. vi. 1858, pp. 53–59). A joint paper on the Foraminifera of the Norwegian coast, published in the Ann. Mag. Nat. Hist. April, 1857, became the basis of a larger memoir, on the Arctic and North-Atlantic Foraminifera, in the Phil. Trans. 1865. A series of papers followed, on the Nomenclature of the Foraminifera, explaining the real relationship of the hitherto published genera and species, recent and fossil. These also, written in conjunction with T. Rupert Jones, from 1859 to 1863, and thence with H. B. Brady also, appeared in the same well-known periodical until 1873. In the meantime notes and papers were given by Parker and Jones on fossil Foraminifera from Auckland (New Zealand), Mount Gambier (South Australia), Malaga (Spain), Italy, Malta, Vienna, Baljik, etc., Chellaston (Rhætic?), the Chalk of Gravesend and Meudon, Mr. Eley's collection, the Cretaceous *Rotalinæ*, and, with Dr. H. B. Brady, the Foraminifera of the Crag, and recent and fossil *Polymorphinæ*, in various publications.[1]

Professor Parker's genius colours all these notes and papers; his wonderful power of analysing the characters of obscure organisms, and of comparing and contrasting the manifold features and peculiarities so recognized, is traceable throughout. His great natural talent of drawing aided much in the work of elucidating the relation of the several specific forms and their manifold varieties.

Together with A. d'Orbigny, A. E. von Reuss, and others, Prof. Parker has done much (and to a large extent with greater exactitude) towards making these Rhizopodal Microzoa known as to definite morphological groups, and as to their exact distribution in various geological series,—thus making them trustworthy guides in the discrimination of strata, whether as to relative age,—of different kinds of sedimentation,—or of various depths of deposition.

Much as we grieve at the loss of so acute an observer and so good a generalizer in one branch of natural science, other Naturalists feel as deeply his loss as of a painstaking and philosophical biologist, whose manifold researches and discoveries in vertebrate development, published in upwards of thirty important memoirs in the Transactions of the Royal, Linnean, Zoological, and other Societies, have had, and still will have, wide-spread useful influences. Not the less will a great circle of friends and relatives long mourn for a great and good man,—an enthusiastic lover of Nature, who sought for truth with simplicity of mind, zeal for accurate knowledge, and kindly consideration for fellow-workers;—an unselfish, upright, and true Christian.

[1] See the Royal Society's "Catalogue of Scientific Papers," and Mr. C. D. Sherborn's "Bibliography of the Foraminifera."

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No. X.—OCTOBER, 1890.

ORIGINAL ARTICLES.

I.—On Variations of the Climate.

By Dr. Edw. Jäderin,
of the Royal Swedish Academy of Sciences.

HOW often do we not hear old people assert that when they were young the climate was quite different; that the weather was warmer or colder, etc.; and even comparatively young people are sometimes of the same opinion. It is most natural to assume that these observers have been misled by the more intense impressions of youth, which cause, for instance, a hot summer, bringing with it more rural pleasures and open-air sports, to be engraved on the mind for life. On the other hand, should the early years be accompanied by much wet weather and storms, these years are perhaps more easily forgotten, as the monotonous and tedious life within four walls to which one is then confined does not leave that distinct impression upon the youthful mind as that of a glorious summer spent out-of-doors. However, the importance of the question and its great general interest demand an investigation of the problem; the more so as certain scientific theories and hypotheses tend to prove that a change in the climate must necessarily take place.

If we assume for a moment that the observations just referred to really were correct, and that besides—as many people also believe—the change, for instance a fall of temperature, steadily continued generation after generation, it will easily be seen that this assumption would lead to absurd results. For, in order to be noticeable in one generation the fall of temperature should at least amount to 1° C., but 1°, say in fifty years, makes 20° in a thousand years, or 40° from the birth of Christ to the present time. If in reality the temperature during these 2000 years has been slightly lowered, the difference cannot, according to the testimony of history, be very considerable, and must, during a generation, be absolutely unnoticeable. Therefore the change which it is assumed has taken place must—if there be any—be *periodical, i.e.* that warm and cold periods of varying degree alternate. Indeed, to this conclusion—and a very important one—our experience is led from every-day life. But further than this we are unable to proceed without a systematic scientific basis for our research.

For a long time geological investigation has demonstrated that the climatic conditions of the earth during earlier geological periods differed greatly from the present. The change referred to must, therefore, be accepted as a fact, but as regards its *nature* there are several probabilities to contend with; for instance, whether it can be traced in a short span of time or at all events in *historical* times, whether it is confined only to *parts* of, or to the *whole* earth, whether it is limited to long or short periods, and, finally, whether the change can be shown to be *still continuing in the same direction.*

The latter question is of course of the highest general interest, as it is closely connected with the history of the earth's development from its first commencement as a planet to its final stage.

In recent times the copious meteorological materials now at our disposal have been analysed, in order to demonstrate the change in the climate within briefer spans of time. It is well known that glaciers are subject to changes in their extension, viz. that during certain periods they advance, and during others retreat beyond their normal limits. Naturally, the cause of this should be sought in the climate, and now, in fact, Forel, Richter, and Lang have demonstrated that this phenomenon in the Alps corresponds with a similar periodicity of temperature and fall of moisture. But the variability of these meteorological factors do not only occur in the Alps, as in 1887 Brückner demonstrated that a periodicity of the rainfall occurs in nearly all countries of the Northern Hemisphere. Of this proof is not only furnished by the rain-gauge, but also by the changes of great duration which take place in rivers, lakes, and in the sea. In the Southern Hemisphere too—as far as we are able to judge from the scanty material at our disposal—a corresponding variability occurs.[1] In fact, according to the latest investigations of Prof. Siegers, of Vienna, upon the level of water in oceans and lakes, this variability of rainfall occurs over the whole surface of the globe.

The temperature of the air, too, is subjected to periodical variations although in a less pronounced degree. On this point it is of interest in winter to study the period during which rivers and lakes are frozen over, as it has been shown that the periodicity coincides with that of the Alpine glaciers.

For the investigation of the circumstances indicated, we have at our disposal material collected at some 500 different meteorological stations, comprising 25,000 years of time of observation, and on the basis of the same we are enabled to declare that the climate of all countries in the world is at a certain time and manner subjected to a change, and that the areas where this is not the case are very limited, indeed they embrace only some coast lines. The varaibility becomes also the more pronounced the further inland we advance.

In the present century the years 1815, 1850, and 1881 mark about the middle of three relatively wet periods, and the years 1830 and 1860 the middle of two correspondingly dry periods.

It would be of interest to know whether the climatic changes are regularly periodical or whether the length of the period suffers any

[1] Vide Stanley's report as to the changes of water-level in the Great Lakes since his last visit.—*Ed.*

alteration in course of time. A long series of records relating to the date of the grape-harvest reaching back to the year 1400, as well as measurements of the level of the water in lakes and rivers up to the year 1700, enable us to fix the average duration of each of the periods in question at 36 years.

The law of the weather theory in general has for a long time been familiar to a large portion of the public. The diurnal synoptic charts show an attentive examiner the connection between the height of the barometer, the direction of the wind, temperature, and rainfall, whilst the charts drawn up for the purpose of showing the annual *means* of the barometer, etc.—*i.e.* the climatic charts—explain the same relation between the meteorological factors. We find, for instance, on one of them somewhere in the Northern Hemisphere an area with an average low pressure, and we shall then also find how the wind, just as on the synoptic charts, which show the state of the weather on a certain occasion, rotates around this area sunwards with a movement towards the centre of the spiral. From this it results that the change noticed in the rainfall must depend upon analogous changes in the direction of the wind and the atmospheric pressure. In a scientific work upon this pressure, based upon observations carried on during many years in Europe and Northern Asia, it is shown that such periodical variations also occur in the barometric pressure.

From observations recorded since 1826 within the Temperate Zone of the Old World, it appears that each rain period, viz. 1841–55, and 1866–85, is followed by a *reduction* of all differences in the barometric pressure, and that each dry period, viz. 1826–40 and 1856–65, is followed by an *increase* of differences in the barometric pressure. Both when speaking of the division of the atmospheric pressure over different *areas* of the earth's surface and in respect of this division during different *seasons* in a certain place, the expression "difference in the atmospheric pressure" is suitable, and a reduction of the differences in the barometric pressure during a certain period indicates a more even division of the pressure than usual over the earth's surface, as well as a smaller variation than the normal during the year.

The change in the barometric pressure explains not only the variation in the rainfall occurring according to the natural law, but also the existence of areas with differing conditions.

Just as on one side the rainfall is dependent upon the variability of the barometric pressure, the latter in turn must exercise influence upon the amount of heat received by the earth, and an increase of the latter during a dry period accentuates the contrast between land and sea.

It would be of additional value to deal with the variations of the climate indicated by Brückner as regards their equal duration and internal relation. They have not only a purely scientific, but a practical importance, as they exercise influence upon changes in the level of lakes and rivers, and thus in many localities the time of their freezing too, and therefore indirectly upon navigation and trade.

Moreover, they directly affect agriculture, particularly on the larger continents. As a proof of this may be mentioned the great increase in the colonization of the North-West American Continent, and the increased rainfall which followed the last dry period, about 1860.

The experience of this comparatively short rainy and stormy period easily explains how people assert that the climate has undergone a change in *one* direction, with just as much justice as other people claim an opposite experience.

Having thus explained the manner in which we may assume that the climate varies periodically or regularly in a uniform or variable manner in different parts of the globe, and that the period extends over 36 years, it would appear from observations that we are at present about the middle of this period, having entered the dry span.

We are, however, aware of other variations occupying much longer periods, which may on account of this greater length exercise a far larger influence upon terrestrial conditions.

We know that Northern Europe even at a comparatively recent geological period was covered with ice, like Greenland at present, and was therefore at that time as uninhabitable as the latter continent is now; but we know, too, that this does not indicate a continuous change in one, certain direction, whereby our climate should steadily become warmer and warmer or that it was equably colder the further we go back in time. For various discoveries made by geologists in the flora and fauna from a period far more remote than the Ice Age show conclusively that at that epoch a climate prevailed in Northern Europe which produced plants and animals similar to those now found in the Tropics. The Ice Age must therefore be considered only an accidental deviation—for a comparatively short period—from the mild climate of pre-Glacial time. To fix the time of this tropical climate is, we must confess, impossible, but the alternating geological strata of the earth appear to indicate that we have here to reckon with hundreds of thousands or may be millions of years.

That this variation in the climate may be connected with the gradual cooling of the earth was formerly an accepted theory, and this with greater reason as it was once assumed that this cooling was general, if not for the whole earth, at all events around the Poles. However, modern *savants* have shown that this is now an untenable theory, as it has been proved that in Japan, for instance, the climate was at a remote period much colder.

At a recent meeting of the Royal Swedish Academy of Sciences Prof. Nathorst demonstrated that the axis of the earth during the geological periods in question has changed its position within the body of the earth itself, and that the North Pole has approached towards us, away from the Japanese side of the earth. From this should have followed a variation of the Polar Meridian of places upon the earth, and this seems also borne out by recent astronomical observations. It has been found that the change is infinitesimal, perhaps only amounting to a second per century, but this second in a century would in a million years make nearly three degrees, in ten million years nearly thirty degrees, etc., if taking place uniformly with time. The cause of the great change in the climate referred to, and the consequent entire revolution of flora and fauna, must therefore, undoubtedly, with full justification be ascribed to the shifting of the earth's axis, the more so as within the earth and upon its surface transfer of matter is constantly going on, which may again account for this shifting of the axis. These changes again may be considered to be, in spite of the length of time, periodical.[1]

There now remains the great question whether the change in the climate is a continuous one in one direction throughout ages. Geologists and astronomers are, as is generally known, almost agreed upon the theory or hypothesis of the formation and development of the earth, as well as other planets, from a chaotic mass in gas or dust form to its present state. This theory demands that the earth in its earliest stages as a planet should have possessed a very high temperature, being in fact a red-hot ball, which gradually cooled through a number of stages until reaching the present one. According to this, then, the earth should have cooled greatly since its first state as a body, and the conditions upon it should consequently at that period have differed greatly from the present, and that this was so is fully verified by the discoveries from the most remote geological epochs. The question is then: is this change of terrestrial conditions still going on, or has it ceased? There is but little possibility of answering this in the near future, but one thing is certain, we must in our researches towards that end measure time by a gigantic standard.

However, it may be pointed out that there is this difference between the early and present stage of the earth, that during the former it was principally its own producer of heat, receiving most of it from within. The atmosphere was enveloped in large masses of vapour, and filled with heavy clouds, through which the sun's rays never penetrated directly. The sun's heat had therefore little effect, and would, even if it did penetrate to the surface of the earth, have been of subordinate importance to that afforded by the earth itself. Since that stage—the earth having cooled—the rôles have been reversed. The surface of the earth may now be considered as receiving nearly all its heat from the sun. If there be still a glowing interior, the heat shows itself only indirectly through volcanic eruptions and hot springs. Should therefore the earth continue to

[1] See on this subject a most valuable and suggestive memoir "On a Possible Cause of Climatal Changes," by Dr. John Evans, F.R.S., F.S.A., Sec. Geol. Soc. (1866); Proc. Royal Society, March 15th; also, Geol. Mag. 1866, Vol. III. pp. 171–174, in which a change in the axis of rotation is advocated, not only as best suited to explain the discoveries of an abundant animal- and plant-life in high northern latitudes, demanding great climatal changes; but also those changes due to upheaval, depression, and denudation of the earth's surface which must affect the earth's equilibrium. Also that astronomical observations tend to show "that the ground itself shifts, with respect to the general earth, or that the axis of rotation changes its position.

cool during time, we may assume that the process will affect the temperature on the surface but little.

There may, however, be an indirect effect, viz. that by a decrease of water in the seas through the earth's absorption the moisture of the atmosphere may become reduced, and in return the earth may lose its protecting veil of clouds.

II.—The Recent and Rapid Elevation of the Ural Mountains.

By Henry H. Howorth, Esq., M.P., etc.

YOU have permitted me recently to publish two short papers in the Geological Magazine in which I have advocated some unconventional views. Perhaps you will allow me to continue my induction.

In the first paper I endeavoured to show that the identity of the living Mammalian fauna of Siberia and North America necessitates our postulating that those areas have very recently, namely, during the Mammoth age, been connected by a land bridge; further that the facts compel us to the conclusion that this land bridge must have been across a portion of the Polar area, and that when it existed comparatively temperate conditions prevailed there.

In the second paper I endeavoured to show that an elevation of the bed of the Arctic sea sufficiently to permit of such a land bridge existing would entirely reverse the drainage of the great rivers of Western Siberia, which, instead of forcing their waters into the Arctic Ocean, would constitute a great Mediterranean sea in Central Asia; and further, that the débris and relics of this sea preserved in the scattered lakes and intervening sand wastes of that area are among the elementary facts of physical geography.

I went on to argue that when the Mammoth and his companions were living, the general slope of the Siberian continent was like that of European Russia, with which it is so closely connected in other ways, namely, that it sloped down from north to south; the Obi and the Yenissei then having very much the same course that the Ural, the Volga, the Don, and the Dnieper have now. The line separating the two great planes, one of which now slopes northward and the other southward, is the Ural chain. If the change took place at the end of the Mammoth period, a view which I have argued in favour of, we ought to find traces of it, and very patent ones, in the Ural chain itself. The object of this short paper is to point out that this is in fact so, and that the Ural mountains are a very recent feature in the geography of Eastern Europe; that they date from the close of the Mammoth period, and were the result of the violent disturbance of the earth's crust which then occurred, and to which I have elsewhere referred.

The view in regard to the Ural mountains here defended is not entirely new. It had already substantially been advocated by Murchison, under whose broad ægis I am well content to shelter; for I deem him, notwithstanding recent discussions, the first in the long rôle of English geologists.

Thefirst and most obvious fact about the Urals which has struck all travellers who have crossed them is that, although a mountain chain virtually running from one sea to another, they form no frontier at all, either botanically or zoologically. The plants and animals are precisely alike on both sides of the range. It is true that the range is not a very lofty one, nor are other ranges which do constitute biological frontiers; nevertheless it is a very remarkable fact that, so far as we know, the Ural mountains do not form a frontier at all. The continuity of life is complete right across them. They have led to no isolation. It seems to me that this can only be accounted for by the circumstance that they are a very new feature in the country.

Secondly, not only are the zoological and botanical features alike on both sides of the range, but also the superficial loose deposits. Those enigmatic continuous beds of black earth—"chernojem" as the Russians call it—which are such a feature in European Russia, are also found on the Asiatic side of the Urals. Whatever their origin, which, like the origin of the loess, is shrouded in so much doubt, they are clearly not marine, and do not preserve any marine debris whatever, and, whether subaerial or a deposit from fresh water, it remains remarkable that they should be precisely alike in texture and contents on both sides of the chain.

Thirdly, and this is a much more direct piece of evidence. It has been remarked by one traveller after another that there are no traces of glacial action in the Urals. Murchison, who examined the chain from north to south with great care, says, "We have indeed fully explained that those mountains and both their flanks are void of all boulders and far-borne detritus. Though exhibiting proofs of interior dislocation, the Ural is therefore a perfect contrast in this respect to the Scandinavian chain. . . . As there is no glacier in the Ural up to 70° N. lat., so, according to the rules of the glacialist, there never can have been one, since there are no moraines, nor any striated and polished rocks in the whole region" (Russia and the Ural Mountains, pp. 527–8).

In an earlier paper he writes: "To the east of Grabovo, the road runs in one of the lateral depressions, and little stony matter is to be seen. The absence of all coarse detritus is, however, a phenomenon which cannot but surprise every geologist accustomed to other mountain chains, for he has now absolutely reached the foot of the central ridge of the Ural, in which there are many lofty peaks, and yet not a single far-transported block can be detected" (*id.* p. 358–9).

It is not only in the chain itself that we miss these unmistakeable proofs of the existence of former glaciers on a large scale. It is the same in the adjoining plains of European Russia, where all the erratics have come from Scandinavia and Finland.

These facts converge very remarkably upon the conclusion that the Ural chain was non-existent at the time when the Scandinavian Mountains were shedding their boulders far and wide, but that they are in fact a very modern feature in the country. The nature of their contour and the way in which the sheets of auriferous gravel and of Mammoth remains upon them occur point further not only to their having been recently but also violently and more or less suddenly elevated.

This is what Murchison, who made a very elaborate examination of the whole chain from north to south, has to say on this point: "It must be recollected that as by other proofs we have already endeavoured to show the comparatively recent elevation of the Ural crest, this region cannot be looked upon as having been rendered highly mountainous until the very period when great numbers of these animals (*i.e.* Mammoths) were destroyed—a destruction which we believe to have been mainly accomplished when the present watersheds between Europe and Asia were determined" (Russia and the Ural Mountains, p. 492). Again, he says, "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 upturned ridges of the Ural*, as well as in the lowlands and great estuaries furthest removed from them (*id.* p. 494). Again, "Such might have been the position and condition of some of these creatures 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.* p. 498). Again, "It has further been proved, that the production of gold veins, and the elevations of the Ural, which have given to these mountains their present height and relief, are phenomena of a comparatively recent date—phenomena which, in lowering the temperature of the great region so affected, were, we have little doubt, the chief causes of the final destruction of the Mammoths, which, with all their adaptation to existence in northern latitudes, could scarcely be supposed to have been capable of long enduring the want of sustenance incident to Siberian winters of the present period" (*id.* p. 605).

I have now brought together such facts as are accessible, illustrating the recent history of the Ural chain, and they seem to me to converge with overwhelming force upon the conclusion that this range of mountains was upheaved more or less rapidly at the end of the Mammoth period. It was this upheaval which, in my view, caused the plain of Siberia to reverse its slope, and its rivers to reverse their drainage, and I agree very much with Murchison's conclusion that it was the floods of water caused by this upheaval which drowned the Mammoths in a considerable area of European and Asiatic Russia, and covered their remains with wide-spreading continuous sheets of gravel and other soft debris. I differ from him in deriving this water from a number of lakes, and would urge, as I urged many years ago, that it was rather the outpouring of the great Asiatic Mediterranean sea. whose relics are so ubiquitous in salt lakes and stretches of marine sand which largely caused the great debacle, and that the upheaval of the Urals was in this way very largely the *causa causans* of the extinction of the Mammoth over a wide area.

Before the upheaval it would seem almost certain that a vast prairie plain stretched from the Carpathians and the Vistula as far as the Yenissei, with a more or less uniform slope towards the south, and draining itself into the vast sheet of water of which the Black Sea, the Caspian Sea, the sea of Aral, and the Balkhash are four notable relics. When the Urals were upheaved, it doubtless set in motion a portion of the waters of this vast sea, which swept over the low country, and distributed the wide-spread mantle of soft deposits far and wide, as we find it spread quite irrespective and independent of the river-valleys.

In another paper you will perhaps allow me to apply the reasoning here used to the Altai and the great plateau of Mongolia.

III.—Invertebrate Palæontology in some Continental Museums.

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

NATURALISTS who refer to their "Baedeker" for information respecting the Continental Natural History Museums are too often disappointed by finding that if the author does happen to have mentioned them, either that he has confined his attention to the exterior of the building or has summarily dismissed the collection as "unimportant." Hence geologists are dependent upon such papers as those in which M. Cotteau[1] has recapitulated the principal contents of several French and Swiss Museums, or that in which Mr. Smith Woodward[2] has enumerated the most interesting specimens of many German and Austrian collections. The last paper, as is indicated by its title, "Vertebrate Palæontology in Continental Museums," is restricted solely to the Vertebrata. But as the value of a Museum, as far as the Invertebrates are concerned, is dependent more on the possession of collections than of single famous specimens, the student of this group is more in need of such information than is the Vertebrate palæontologist; every one knows where he must go to see an *Archæopteryx*, a mounted *Iguanodon*, or a Neanderthal skull, but the last resting-place of a local collector's hoard is, as a rule, less known to fame. Hence the following notes may be of some service as a supplement to Mr. S. Woodward's paper.

Hamburg.

The palæontological collection is at present mostly stowed away in packing cases at the Johanneum, awaiting removal to its new home in the spacious Museum recently erected in the Steinthorwall. But by the kindness of the Curator, Prof. Dr. Gottsche, I was enabled to examine most of the Echinozoa, especially the valuable series, including some well-preserved Ophiuroids, from the glacial deposits of Northern Germany. There are also collections from the limited exposures of the Oligocene and Cretaceous in the same district. The fossils from Lüneberg are less numerous than in some

[1] "Rapport sur les Musées d'histoire naturelle de quelques-unes des villes du Sud-ouest de la France," Ann. Instit. des provinces, 1868. "Notes sur quelques Musées d'histoire naturelle de la Suisse et de l'Allemagne du Sud," Bull. Soc. Sci. hist. et nat. Yonne. xxiii. 1869.
[2] Geol. Mag. (3) V. 1888, pp. 395–404.

other Museums, no doubt mainly because the local knowledge of the astute curator has enabled him to detect and reject all the specimens imported into that town to make the limited supply more equal to the demand. There are some interesting teratological specimens from the glacial beds of the neighbourhood of Hamburg, one of which, a deformed *Galerites*, has a considerable influence on the true systematic position of that genus. The same drifts have yielded a good series from the Danien of Faxoe, while the large collection from the Upper Cretaceous of South Africa reminds the visitor of Prof. Gottsche's travels.

The contents of the Godeffroy Museum have already been removed to the new building, where the Director, Dr. Kraepelin, and his assistants, have temporarily arranged most of the zoological collections. The Echinoderms, including an extensive series from West Africa, have been classified by Dr. Pfeffer. Dr. Meiklesohn is engaged upon an index collection similar to that at the Natural History Museum, and several of his preparations are of especial interest to palæontologists.

Berlin.

The "Museum fur Naturkunde" (at 43, Invalidenstrasse, just outside the Neue Thor) is that which will probably first attract the attention of the visitor. The Palæontological Department contains a fine series of type collections, many of which are associated with the work of the members of the staff. Thus it includes the collection of Prof. Dr. Beyrich, the present head of the Department, and many of the specimens described in the memoirs of Prof. Dr. Dames and Dr. E. Koken. Amongst other collections there are those of Leopold von Buch, and of Schlotheim; Fischer of Munich's great collection of Alpine fossils; many of Goldfuss's Corals and Bivalves and Mojsisovic's Triassic Cephalopoda; the best of the originals of Eck's *Trichasteropsis senfti* from the Saxon Muschelkalk, and half of the collection of Bundenbach Asteroidea, described by Herr Stürtz in his earlier monograph. The Museum seems also rich geographically; thus among the Echinozoa, in addition to the ordinary Continental localities, Greece, Persia, Egypt, Texas and others of the United States, Australia, etc., are all represented. There is too a good collection—as collections go—of the Echinoidea of the Alpine Trias, including a perfect specimen of the remarkable genus *Tiarechinus*; as the only hitherto recorded specimens are the two in Vienna, the opportunity for the examination of this was a very pleasant surprise. The greatest treasure of the Museum, it need hardly be remarked, is the second specimen of *Archæopteryx*.

Immediately adjoining the "Museum fur Naturkunde" is that of the "Geologische Landesanstalt und Bergakademie," in which is preserved a large stratigraphical series from Prussia and the Thuringian States. Amongst others it contains the collections of Koch and Dannenberg from the Devonian of the Rhine valley and the Tertiary of the Mainz basin: of Richter from the Silurian and Devonian of Thuringia: of Menzel from the Silesian Muschelkalk: of Schlömbach, Braun and Lasard from the Jura and Kreide of Bremen and

Hanover: of Becks from the Westphalian Kreide: of Zeigler from the Gault of Ahaus: of Speyer from the Hessian Tertiary: of Küsel from the Bukower Tertiary: of Meyn, Kloeden and Gumprecht from the North German "Flachlande": of Kovalevski from the Samland Bernstein; and finally Beinert's Carboniferous plants.

Dresden.

In one corner of the Zwinger, in the picturesque old town of Dresden is the Mineralogical and Palæontological collection presided over by Prof. Dr. Geheimrath H. B. Geinitz and Dr. J. V. Deichmüller. The collections (open from 9 till 1) contain most of the types figured in the various monographs of the "Mittheilungen aus dem K. Mineralogischen Museum in Dresden," such as Prof. Geinitz's from the Saxon Dyas, or Dr. Deichmüller's insects from the Solenhofen stone. It also contains a choice series of fossils from the Cretaceous rocks of Saxony. Among the Echinoderms of this collection the gems are certainly the fine set of Asteroidea, the genera of which, however, require re-examination in the light of Mr. Sladen's recent *Challenger* Report; at present they are all included as *Stellaster*; but one at least (*S. albensis*, Gein.) must be included with *Nymphaster*.

At Dresden the geologist need not regret as much as at many towns the shortness of the hours during which the Museum is open. Though the palæontologist may feel little interest in the art treasures of the Zwinger, the geologist can profitably spend a few hours in the study of the landscapes of pre-Whistlerian 17th century impressionists; the unrivalled series of Ruysdael's and several of the rather rare works of his master Albert van Everdingen may be profitably compared with such masterpieces of 19th century realism as Papperitz's gneissose mountains (No. 2240) or Eug. Düncker's boulder bestrewn beach, or the roches moutonnées in Hemming von Kameke's Alpine landscape.

Prag.

The scenery of Saxon Switzerland, with the deep valley of the Elbe bounded by flat topped hills often crowned with some picturesque old castle, forms a pleasant contrast to the sandy tracts of the North German plain. The geologist certainly should do this section of the journey by daylight; he can join with those whom a philanthropic age has sent to tenant the castles that surmount these historic hills in a philosophic contemplation of the precipitousness which cliffs of ordinary soft "kreide" can maintain when protected by a basalt cap.

At Prag the Museum is still in the old building in the Graben and the palæontological collection is displayed in a summer house in the garden. It will however be shortly removed to the colossal Bohemian National Museum now rapidly approaching completion at the end of the Wenzelplatz.

The principles upon which the new museum is to be arranged and the methods by which these are to be carried into effect are fully described in Dr. A. Fric's paper "Principien der Organisation der naturhistorischen Abtheilung des neuen Museums zu Prag."

The two most important collections in the Museum are those of Barrande and Sternberg. The latter is supplemented by a number of Feistmantel's types.

There is a small series of fossils from the minute patch of limestone that represents the Jurassic system in Bohemia. The Cretaceous collection is of course much more extensive; the originals of Dr. A. Fric's memoirs on the Crustacea of the Bohemian chalk are mostly preserved here, including his *Loricula pulchella*, var. *gigas*, the finest of the known fossil Cirripedia. The Museum also contains many of the types of Dr. Novak's admirable memoirs on the Bohemian Cretaceous Echinoidea and Bryozoa.

The second Museum at Prag is that of the German University (Naturwissenschaftliches Institut in Weinberg Gasse), of which the geological department is under the care of Prof. Dr. G. C. Laube. The collection, though not large, is one that well repays a visit, as it contains many types, as, e.g. of the Cretaceous Crustacea, which supplement the series in the National Museum. Most of the originals described in Laube and Bruder's work on the Ammonites of the Bohemian Kreide are to be seen here.

There is yet a third collection, of which Prof. Dr. O. Novak is the curator, at the Bohemian University.

Vienna.

In the Austrian capital there are three geological collections each of the first importance, those of the Hof Museum, of the University, and of the k. k. Geologisches Reichsanstalt. The first of these is a palatial edifice in the Ringstrasse, and is probably the finest museum building on the Continent. The geological department is under the care of Dr. Fuchs, who has as his assistants Dr. E. Kittl and Dr. K. Wähner. The arrangement of the department is at once both instructive and interesting. The fossils are grouped stratigraphically in table cases: in wall cases around the rooms are collections of the rocks of the same formations, and above are views showing how they occur in the field. Thus the student of the fauna of any horizon can easily refer to the series of sedimentary rocks which illustrate the physical conditions of the period, while the pictures above show the beds in their typical development in the Austrian Empire. For example, above the Miocene rocks is a view of the great quarry of Margarethen in the Leithagebirge, and over the Jurassic is one of Csorsztyn in Galicia illustrating the Carpathian "Klippen."

The palæontological collection is not yet fully arranged, but by the courtesy of Dr. Fuchs it is all available for reference. It includes a fine series of Bohemian and Leithakalk fossils, and of those from the Tertiary of the Vienna Basin; many of the best of Laube's types from the St. Cassian Schichten are to be found here. The foreign collections are extremely rich, and they include those made during the voyage of the "Novara" and the types of Laube's Echinoids from the Murray River beds, the most important historical collection of Australian fossil Echinodermata. The plant collections are especially extensive. The department also includes a most instructive collection illustrating dynamical geology, and in connection with this are views of glaciers, volcanoes, and other geological agents.

No reference to the Hof Museum would be complete which omitted to notice the meteorite collection, which is claimed to be the finest in the world. Its principal treasures are well known from the description of its curator, Dr. A. Brezina, in the Jahrbuch k. k. geol. Reichsanstalt for 1885. In the same room is the splendid petrographical collection arranged by Dr. Berwerth.

The University of Vienna is also on the Ring Strasse a few minutes' walk from the Hof Museum. Both the Geological and Palæontological Schools have valuable collections. The latter is of especial interest as having been made by the late Prof. Neumayr. The general geological collection is under the care of Prof. Dr. Suess, and it includes much new material, which is being described by Dr. A. Weithofer.

The faunas best represented—at least among the Echinodermata—are those of the Leithakalk and the North Italian Eocenes; several of the types of Bittner and Laube are to be found here.

The third collection in Vienna is that of the Geologisches Reichsanstalt in the Liechtenstein Palace in Razumoffsky Gasse. Here there is a very extensive Austrian collection, including many of the types of the species of the Director, Dr. Stur, and of Dr. Mojsisovics, Dr. Bittner and other members of the staff. The Triassic Cephalopoda, and Vicentin Echinoidea, and the collections from the Tertiaries of the Vienna basin, and of Galicia and Hungary, the Weisser Jura of Maehren, and Laube's types of Corals, Sponges, and Echinoderms, are especially worthy of notice. The type of Neumayr's *Tiarechinus* is one of the gems of the Museum. General geology is not neglected, and there is a good series of rocks and specimens illustrating the stratigraphy of the Austro-Hungarian Empire.

Munich.

The Museum of the "Akademie der Wissenschaften" in Munich is probably that which will tempt the palæontologist to linger longest; for not only is the collection itself remarkably complete, but it includes a series of most important historical specimens, and by the courtesy of Prof. von Zittel it is available for study from 8 a.m. till 6 p.m. Foremost among the special collections is that of Baron Münster, including many of the specimens figured in Goldfuss and nearly all of those in the "Beiträge zur Palæontologie." Schafheutl's Bavarian collection, with all the Kressenberg types, also contains some very valuable material. Among the Echinodermata the following are especially worthy of notice: the Echinoidea from the Stramburger Schichten described by M. Cotteau: many of the best of the Asteroidea of Dr. E. Fraas' monograph: the *Echinopsis pusilla* redescribed by Dr. Ebert: a few of the types of Quenstedt's "Der Jura": of Prof. Dames' memoir on the Echinoidea of the Juras of the North-west of Germany, and most of the specimens from which were made the original illustrations in Prof. von Zittel's great "Handbuch." The Solenhofen Echinoidea are represented by a series in the Haberlein collection and by the types of Bohm and Lorie's "Die Fauna des Kehlheimer Diceras Kalkes."

In other groups, the type series are not less important. Thus, in the Medusidæ, there are the specimens figured in Oppel's Beiträge, and in the memoirs of Häckel and von Ammon. The collection of Annelida include the most important of those described in Prof. Ehler's monograph, besides many types from the various general collections. The Crustacea are represented by an extensive series of important specimens: amongst others there are those described by Münster in his "Beiträge" and by Oppel in his "Mittheilungen," including some fine Isopoda and Cirripedia; also the Xiphosura used by Van der Hoeven in his "Recherches sur Limulus." The Sponge collection need hardly be mentioned, as Prof. von Zittel's work has for ever made it famous. The Brachiopoda and Mollusca include a miscellaneous series of types, as, *e.g.* many of those of Oppel's memoir "Ueber die Brachiopoden der unteren Lias," and of the various monographs of the "Geognostische Palæontologische Beiträge." The Cephalopoda include some remarkably fine specimens of the Belemnoteuthidæ and Chondrophora.

In addition to the general collection, which is classified zoologically, there is a supplementary stratigraphical series.

The Museum of the Bavarian Oberbergamt at 16, Ludwigstrasse, contains a collection illustrating the geology of that kingdom. The petrological collection is the most important feature in the Museum, containing as it does the rock specimens described by the Director, Prof. von Gümbel, in his "Die paläolithischen Eruptivgesteine des Fichtelgebirges," and his "Geognostische Beschreibung des Konigreichs Bayern."

Stuttgart.

The Museum of the Würtemberg capital is especially famed for its Vertebrate treasures, and there is nothing among the Invertebrates that can equal in interest the great slab of *Aetosaurus*. Nevertheless it is well worthy a visit, as it contains an extensive collection from the Jurassic and Triassic rocks of the neighbourhood. Here are to be seen many of the types of Quenstedt's last work "Die Ammoniten des schwabischen Jura," besides a few of those of the "Petrefactenkunde Deutschlands," as, *e.g.* his interesting *Ophiura ventrocarinata*. Some of the Crustacea figured by Oppel, the finest of the *Plicatocrini* that illustrate Prof. von Zittel's memoir, Eck's *Trichasteropsis cilicia*, and Münster's *Asterias wissmanni*, are among the most important of the Invertebrates. There is also the extensive collection made by the Director, Prof. Fraas, in Syria and Egypt, and including the types of Prof. Dames' memoir on the Crustacea. African palæontology is represented by the collections made by Baron Ludwig, Dr. Krauss, and Dr. Holub.

Tübingen.

On the brow of the central hill of Tübingen, where the steep slope that rises from the Neckar passes into the platform that bears the Stiftkirche and commands a wide view over the Jurassic rocks of Suabia, is the Museum that will ever remain as a monument to the memory of the late Prof. von Quenstedt. The collection is a most interesting one, and even Baedeker remarks that it "deserves attention," though he only mentions the big 24-foot long Ichthyosaur, a fossil, however, which is dwarfed into insignificance by the clump of 70-foot Crinoids. It is unnecessary to refer to the special features of the Museum, as its contents may be summarized as the collection of Prof. Quenstedt, including the majority of the originals of the illustrations of his various works. To examine these every student of Jurassic palæontology must visit Tübingen, while the physical geologist cannot fail to learn much from a study of this, probably the best collection ever made to represent a fossil fauna.

Heidelberg.

Though there is little or nothing among either the Invertebrates or Vertebrates that would induce a palæontologist to visit Heidelberg, he may well be excused if he turn aside to see the great petrographical collection of Prof. Rosenbusch. Certainly, no geologist who goes to Southern Germany should fail to examine it. The collection illustrating rock metamorphism and the origin of the crystalline schists is especially noteworthy; all phases of this controversy are illustrated, from the Norwegian mica-schists with Trilobites' tails, to the disputed Nufenen Schiefer and the "spotted rocks" of Scopi.

Bonn.

Like so many of the German Museums, that of Bonn has recently changed its quarters. The collections have been moved from the Poppelsdorf to the University, and they were still in the packing cases at the time of my visit. Goldfuss's collection and the second half of Sturtz's first series of Bundenbach Echinoderms are preserved here.

The stock of Herr Sturtz (No. 2, Riessestrasse) always contains some novelties, and is well worthy of examination.

In conclusion, it remains to again express my warmest thanks to those whose unvarying courtesy and kindness rendered my visit to the Museums under their care as enjoyable as it was instructive.

IV.—On the Structure and Stratigraphical Relations of Rhobell Fawr.

By Grenville A. J. Cole, F.G.S., and

Thomas H. Holland, A.N.S.S., Berkeley Fellow of the Owens College.

In a paper dealing with some phases of volcanic action in North Wales,[1] it was urged that contemporaneous eruptive rocks occurred on Cader Idris at lower horizons than the acknowledged base of the Arenig, although the actual vents from which they had arisen were lost and concealed under later accumulations. It was

[1] Cole and Jennings, "The Northern Slopes of Cader Idris," Q.J.G.S. vol. xlv. (1889), p. 437.

pointed out that the mass of Rhobell Fawr was of composite character, but was probably distinct from the series on Cader Idris. The fragmental character of much of its material having been recognized by the author of the Survey-Memoir, several theories are discussed in that work to account for its stratigraphical position.[1] In spite of the lack of detail, when compared with other areas, with which Rhobell Fawr has been represented on Sheet 75 S.E. of the Map of the Geological Survey, the ashes, "breccias," and other materials piled here upon the edges of the Lingula Flags are fully dealt with in the text of the Memoir, and we are left finally to select the most probable explanation of those put forward. Mr. Clifton Ward, quoted on p. 59, suggested that this centre of eruption broke out "after the close of the Tremadoc-slate period," the material thrown out being slightly different in character to that of the widely spread Arenig and Llandeilo series. Prof. Ramsay (on p. 74) seems also to hold this view, suggesting in addition that there is local unconformity between the Tremadoc and the Arenig series, whereby the "Arenig" volcanic rocks of Rhobell Fawr come to lie upon the denuded edges of the Lingula Flags. The remaining view hinted at in the Memoir is that the volcano of Rhobell Fawr is older than the Tremadoc slates. In the present paper, however, at the risk of multiplying explanations, we hope to bring forward evidence to show that it is in reality contemporaneous with the Tremadoc.

Mr. Clifton Ward, when mapping the Grit that has been regarded as the base of the Arenig in this area, records the discovery of "an oblong, angular block of grit" a little below the summit of Rhobell Fawr, "but no traces of the grit-bed were met with."[2] Whether or no we lay stress upon the continuity of a lithological horizon across a considerable area, there is no doubt that in this case gritty beds occur only a mile away on Allt Lŵyd, above the Tremadoc slates and below the Arenig volcanic series; hence a similar occurrence on Rhobell Fawr, as Mr. Ward perceived, would have a real and valuable bearing on the age of the underlying fragmental rocks.

Rhobell Fawr appears as a broad rugged moorland indented on the south-east side by a marked semicircular hollow, on the margin of which the two most distinctive summits rise. The more northern of these is Rhobell Fawr proper, reaching to a height of 2408 feet above the sea-level; the more southern is Moel Cors-y-garnedd, about 1650 feet high. On the northern slopes of the volcanic mass there are several picturesque little prominences, notably Rhobell-y-Big, some 1580 feet in height.

During a recent examination of the area, we have succeeded in finding bands of quartzose grit both on the summit of Rhobell Fawr and of Moel Cors-y-garnedd. In each case the bed is thin, measuring about one foot at the former point and three and a half inches at the latter.

On Moel Cors-y-garnedd this grit forms a patch underlying the

[1] A. C. Ramsay, "The Geology of North Wales," 2nd edition (1881), pp. 58 and 71.

[2] Ramsay, *op. cit.* p. 58.

rocks of the actual summit, which consist of light-coloured ash without distinct stratification. On its western side the grit is exposed along a north and south line for about 80 yards, and is seen to dip slightly to the east. Beneath it is an extremely characteristic slaty ash, dark and well bedded, with white or grey bands of coarser felspathic material. Intrusive dolerites come up from below into the series and locally affect its members.

The grit itself contains quartzite pebbles, sometimes three-quarters of an inch in diameter, together with numerous rounded fragments of black shale. Here and there rolled lumps of andesite occur, resembling those of the less basic tuffs of Rhobell Fawr. A thin parting of shale underlies the grit at places, dividing it from a layer of cemented sand. The shale-pebbles frequently lie with their longer diameters at a high angle to the planes of stratification, as though they had been rapidly hurried along by a current and banked up in the surrounding sand. The larger examples of these black lumps, which may have been only slightly consolidated when washed into the grit-bed, have developed a delicate concentric shell-structure by contraction, and often, in form and in the markings on their fractured surfaces, present a curious resemblance to Nummulites.

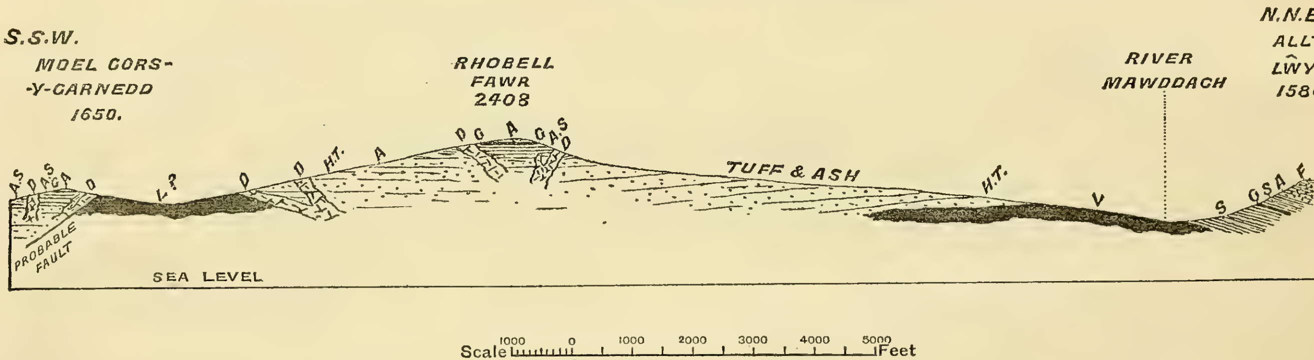
Lower down on Moel Cors-y-garnedd, in a hollow to the north-west of the summit, grit may be seen again, containing rather coarse pebbles of andesite; and on the bank rising to the east of this hollow there is a further exposure of grit in a bed having the thickness and characters of that occurring on the summit of Rhobell Fawr. The bed, which dips south-east, is exposed along a line running north-east and south-west. We have thus probably two distinct beds of grit on Moel Cors-y-garnedd, one of which resembles the grit of Rhobell Fawr, whilst both, curiously enough, coincide in thickness and relations with the two bands of grit which we shall mention as occurring on Allt Lŵyd.

The summit of Rhobell Fawr is similarly encircled by exposures of quartzose grit, which correspond in character with the lower bed on Moel Cors-y-garnedd. This grit is best seen to the north-west of the 2408 point, where it has an easterly dip. The dip, however, varies, and, by crossing the adjacent boundary-wall, several outlying exposures are encountered, much disturbed by the invading dolerites. On the south-west of the summit the grit is replaced by a sandy ash; and it graduates down into a similar bed along its best defined outcrop. Below it are the characteristic slaty ashes, precisely as at Moel Cors-y-garnedd; while above are bedded but coarser ashes. Hence the two conspicuous crests of the denuded volcanic area appear to owe their origin to the presence of these relics of a once continuous gritty layer. The metamorphic action of the intruding dolerites may have given the bed at both points local powers of resistance.

In order to compare the grits of Rhobell Fawr with those recognized as of Arenig age, we examined the steep front of Allt Lŵyd ("Rallt Llwyd" of the one-inch map), which rises close at hand, facing the volcanic area. The typical grey quartz-grit occurs here

SECTION ACROSS RHOBELL FAWR

FROM ALLT LŴYD TO MOEL CORS-Y-GARNEDD, N. OF DOLGELLEY, N. WALES.



G. Bands of Grit.
S. Slate.
A.S. Ashy Slate.
A. Ash.

H.T. Tuff with Hornblende crystals.
L. Lingula Flag series.
D. Dolerite.
F. "Felstone" series of Arenig age.

about 250 feet above the Afon Mawddach, or 1200 feet above the sea. The beds dip from 25° to 30° to the north-east, and, if continued across the valley, would rise easily towards the crest of Rhobell Fawr. Below the grit is a series of imperfect slates, regarded by the Survey as Tremadoc; while beneath these, on the opposing slope, undoubted Lingula Flags occur. Above the main grit-band come about seven feet of slates; then a thin upper seam of grit. Both these beds, as on Moel Cors-y-garnedd, contain black argillaceous pebbles as well as quartz. Higher up follow more slates, and then finely-bedded ashes like those associated with the grit on Rhobell Fawr. Lastly we have the well-marked Arenig volcanic series, with its grey massive "felstones" or eurites, forming the dip-slope of Allt Lŵyd and the summit-cliff of Ddualt, the latter lying immediately to the south.

We have found a pebble of pisolitic iron-ore high upon Allt Lŵyd, and the bed occurs *in situ* below the eurite on the hill east of Llanfachreth.

The base of the ashes and agglomerates of Rhobell Fawr admittedly rests upon Lingula Flags. The slaty beds of this series, with the peculiar black streak mentioned by Belt as characteristic of his "Dolgelly Group," may be traced all round the area, and notably upon the north near Rhobell-y-Big. In the beautiful little gorge of the Afon Geirw, the igneous rocks are distinctly intrusive, and the Lingula series is considerably contorted and crumpled; but in the moor east of Rhobell-y-Big the hornblendic ashes that constitute the remarkable basement-layers of the volcano can be seen in direct contact with slates containing *Orthis lenticularis* and numerous fragmentary remains of small Trilobites. Careful search in this district should reveal many of the fossil forms already known from Moel Hafod-Owen.

This junction with the volcanic series is well exposed in the little stream-cut, about 1300 feet above the sea, descending to the Mawddach at Dol-y-cynafon. The great mass of hornblendic ash and tuff rises above, as is clearly shown at Graig Fach some two miles further to the south. As Professor Ramsay has pointed out, there is no evidence to connect the volcanic series with the Lingula Flags. It occurs upon the highest members of that series, without the intervention of Tremadoc beds; but at the same time it differs in lithological characters from the adjacent volcanic products that undoubtedly overlie the Arenig grit.

The apparent thinness of the Tremadoc Slates in this area has caused some trouble to stratigraphers; but, supposing a fault to occur along the foot of Allt Lŵyd and of Ddualt, this only serves to increase the difference of level and of relations between the series of Rhobell Fawr and that of the Arenig "felstones." The position of the grit-beds on Rhobell Fawr seems to greatly strengthen our contention, viz. that this mass represents a volcanic outbreak occurring between the deposition of the latest Lingula Flags and the Arenig grit, and consequently of Tremadoc age.

The earliest outbursts were doubtless accompanied by considerable movement of the sea-floor, allowing even of local denudation; while hollows may have been formed by the explosive action, though there is a marked absence of the tuffs with slate-fragments that are so conspicuous on the slopes of Cader Idris.

The coarse hornblende-ash, with its handsome crystals, a rock perhaps unique in Wales, passes into more fine-grained types as the summit of the hill is neared. At the close of activity we find, both on Rhobell Fawr and Moel Cors-y-garnedd, a return to normal sedimentation, the formation of shaly layers, and the incoming of the beds of grit. The latter were deposited by waters flowing not only over ancient quartzites, but over andesitic cones, which had at one time risen well above the sea.

To the east, in the area of Allt Lŵyd and Ddualt, ordinary sediments were contemporaneously formed; and when the volcanic activity diminished, and the vast mass of erupted matter sank into the shattered and yielding Lingula Flags through which it had been projected, a common undisturbed sea-floor was re-established, and the sandy layers were deposited over all alike. The intrusive dolerites, which, with the other rocks, we hope to subject to closer petrological examination, may or may not prove to be connected with the fragmental deposits of Rhobell Fawr. In any case we cannot but regard this volcano as commencing in Tremadoc times, and as a precursor of the great Ordovician eruptions; and the existence of such sporadic outbursts must be taken into account as a disturbing cause when we seek to correlate the strata below the Middle or basement Arenig of North Wales with those of other areas.

We append a section, in the preparation of which we have been greatly aided by the new Ordnance maps on the scale of six inches to the mile. Considering the absence of the hornblendic tuffs on the east of Moel Cors-y-garnedd, and the close resemblance of the beds beneath the grit to those on the summit of Rhobell Fawr, we have represented the great mass of the tuffs at the former point as cut out by an oblique fault, which would account for the low position of the grit-series and its proximity to the black Lingula Flags. The vertical scale of the section is the same as the horizontal, so that distortion of dip or of the relations of the several exposures of the grit is, we trust, avoided.

During our examination of the area of Rhobell Fawr, we have been frequently in communication with Mr. G. J. Williams, F.G.S., who has remarked, among other notes, upon the similarity of a specimen of the grit of Moel Cors-y-garnedd and the typical Garth grit of the Ffestiniog area.

V.—On the Occurrence of *Lemmings* and other Rodents in the Brick-Earth of the Thames Valley.

By E. T. Newton, F.G.S., F.Z.S.

NOTWITHSTANDING the large number of Mammalian remains which have been found in the Brick-Earth of the Thames Valley, they have for the most part been portions of the larger forms, and very few examples of the smaller Mammals have hitherto been discovered. Professor W. Boyd Dawkins and Mr. W. A. Sanford (Brit. Pleist. Mam. Pal. Soc. vol. for 1864, p. xxxvi, 1866) have noticed the occurrence of *Arvicola amphibia* in the Pleistocene of Ilford, Crayford, and Erith; while from the last-named locality Mr. R. W. Cheadle (Proc. W. London Sci. Assoc. vol. i. p. 71, 1876) recorded the remains of *Spermophilus*, which Mr. Lydekker has more recently (Cat. Foss. Mam. Brit. Mus. part i. 1885, p. 212) referred to Falconer's species *S. erythrogenoides*.

Several species of small Rodents have been discovered in Pleistocene deposits in other parts of England (see Sanford, Quart. Journ. Geol. Soc. vol. xxvi. p. 124, 1869, and Blackmore and Alston, Proc. Zool. Soc. 1874, p. 460), and it seemed likely that they would be found also in similar deposits of the Thames Valley. As no such specimens were to be found in the British Museum, and only one was preserved in the Museum of Practical Geology, I applied to several friends who had made collections from these deposits; but the result was far from satisfactory. However, Mr. Spurrell and Mr. Cheadle each possessed, in addition to the remains of *Spermophilus*, some Arvicoline bones, teeth and jaws, and I am under obligation to both my friends for readily placing their specimens in my hands for determination, thus enabling me to record from the Brick-Earth of the Crayford district two species of *Myodes* (Lemmings) and an Arvicola (Vole), not hitherto known to occur in that district.

The teeth of these Rodents are very characteristic, and the species may therefore be determined with certainty, but the limb-bones cannot so easily be correlated with the teeth.

Microtus (*Arvicola*) *amphibius*, Linn., sp.

The only specimen from the Brick-Earth of the Thames Valley which I can with certainty refer to this species is a portion of a lower jaw, from Ilford, in the Cotton Collection, preserved in the Museum of Practical Geology. All the remains of Arvicolidæ from Crayford and Erith, which I have seen, are referable to one or other of the species noticed below.

Microtus (*Arvicola*) *ratticeps*, Key and Bl., sp.

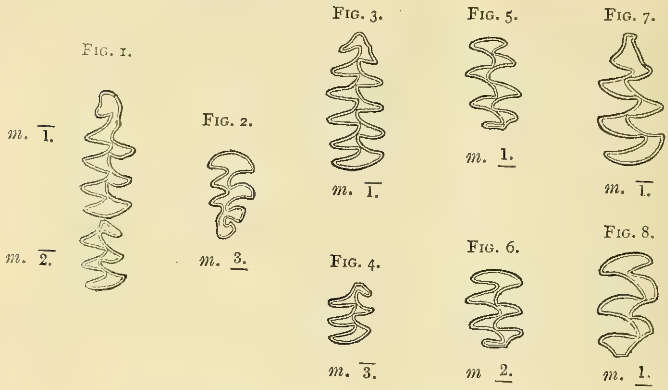
A right ramus of a lower jaw, with two grinders (Fig. 1) in place, together with isolated teeth, from Crayford, in Mr. Cheadle's Collection (now preserved in the Museum of Practical Geology), and three lower jaw rami and several teeth in Mr. Spurrell's Collection, from Erith, are referred to *Microtus ratticeps*.

The most characteristic tooth of this species is the anterior grinder of the lower jaw (Fig. 1, *m* 1), which has five angles on the inner side and three on the outer side, the two anterior and outer columns having coalesced to form one cement space with a nearly flat outer wall. There are differences to be observed, among the specimens from the Thames Valley, in the form of this anterior and outer column, the example figured being rather larger than some of the others, and more nearly resembles the figure given by Messrs.

Blackmore and Alston (*loc. cit.* p. 465), who call attention to similar variation which they have noticed in this species. The second lower grinder (Fig. 1, *m* 2) has three inner and three outer angles, but this tooth is not characteristic. There are several examples of the peculiar last upper grinder of this species (Fig. 2), which has four inner and three outer angles, with the hinder end of the tooth curved and hook-like.

The occurrence of this species in the Thames Valley has already been noticed in Mr. Whitaker's Geology of London and Parts of the Thames Valley (Mem. Geol. Survey, p. 336, 1890).

At the present day *Arvicola ratticeps* is found in the more northern parts of Europe and Asia.



EXPLANATION OF FIGURES.

Patterns of grinding surfaces of teeth of Arvicolidæ from the Brick-Earth of Crayford and Erith.

FIG. 1. *Microtus* (*Arvicola*) *ratticeps*, right lower molars 1 and 2.
,, 2. Ditto, right upper molar 3.
,, 3. *Myodes torquatus*, right lower molar 1.
,, 4. Ditto, right lower molar 3.
,, 5. Ditto, right upper molar 1.
,, 6. Ditto, right upper molar 2.
,, 7. *Myodes lemmus*, right lower molar 1.
,, 8. Ditto, right upper molar 1.

All the figures five times natural size.

Myodes torquatus, Desm.

Mr. Spurrell possesses a single example of this species from Erith, and the specimen consists of a portion of a right mandibular ramus with the first and third molars complete and *in situ*; but only a fragment of the second tooth remains. Embedded in the same piece of matrix, and in natural relation to the lower jaw, is a portion of the right maxilla with the first and second grinders in place, but the third, hinder molar is wanting. The camera-lucida drawings of the patterns of these teeth (Figs. 3, 4) will be found to agree so exactly with those of *Myodes torquatus* as to leave no doubt as to their specific identity.

The anterior lower grinder has six inner and five outer angles, while the last lower grinder (Fig. 4) has three inner and three outer angles, with five cement spaces, the anterior outer space being distinctly smaller than the others. The anterior upper grinder (Fig. 5) has four inner and four outer angles, with seven cement spaces, the hindermost of the inner spaces being rudimentary. The second upper grinder (Fig. 6) has four inner and three outer angles with six cement spaces, the hindermost of the inner spaces being again rudimentary.

There is in the Museum of Practical Geology another specimen, referable to this species, from the Brick-Earth of Murston, near Sittingbourne, Kent. It comprises parts of both upper and lower jaws, very much crushed, but with the upper incisors, and, fortunately, one of the anterior lower grinders preserved. The pattern of the last-named tooth, with its six inner and five outer angles, leaves no doubt as to its belonging to *Myodes torquatus.*

At the present day *Myodes torquatus* has a circumpolar distribution; but is rare in Greenland, and is said not to occur in Russian Lapland.

Myodes lemmus, Linn.

Another specimen from Erith, in Mr. Spurrell's Collection, is to be referred to *Myodes lemmus*; it is a part of a lower jaw embedded in matrix, with the two incisors and the right and left anterior grinders in place; there are also fragments of the upper jaw including the right and left anterior grinders.

The lower front grinder (Fig. 7) is characterized by four inner and three outer angles, with five cement spaces; while the upper front grinder (Fig. 8) has three inner and three outer angles, with five cement spaces.

Myodes lemmus is living at the present day; but is restricted to Scandinavia and Russian Lapland.

The Rodents now known to occur in the Brick-Earth of the Thames Valley are:—*Castor fiber*, Linn.; *Spermophilus erythrogenoides*, Falc.; *Microtus* (*Arvicola*) *amphibius*, Linn.; *Microtus* (*Arvicola*) *ratticeps*, Key. and Bl.; *Myodes torquatus*, Desm.; and *M. lemmus*, Linn.

VI.—Vertebrate Palæontology in some American and Canadian Museums.

By A. Smith Woodward, F.G.S., F.Z.S.,

of the British Museum (Natural History).

(*Concluded from the September Number, page* 395.)

Washington.

The collection of Fossil Vertebrata in the National Museum at Washington is at present insignificant; and the only type-specimens observed by the writer are the fish-remains described by Prof. Leidy under the names of *Clupea humilis*, *Cladocyclus occidentalis*, *Phareodus acutus*, and *Lepidosteus simplex*, besides some fragmentary specimens from the Hamilton Group made known by Prof. J. M. Clarke in the Bull. U. S. Geol. Survey, No. 16 (1885). The palæontologist interested in the lower vertebrates, however, finds much to occupy him in the collection of recent fish skeletons made by Prof. Theodore Gill, who has contributed perhaps more than any other ichthyologist to our knowledge of those parts with which the palæontologist is alone able to deal. At the time of the writer's visit, Prof. Gill was occupied with an investigation of the skeletal anatomy of the eels; and a large number of beautiful drawings of the cranial osteology of various great groups of bony fishes, as yet in the Professor's portfolio, are intended for the basis of a forthcoming general work, to which all who are interested in palæichthyology will anxiously look forward.

Rochester, N.Y.

No European regards a tour on the American Continent complete without at least a brief visit to the remarkable cataract of Niagara, whether regarded merely as a scene or as a noteworthy geological phenomenon; and the palæontologist feels an additional attraction in that direction from the close proximity of Rochester, where Prof. Henry A. Ward has his well-known emporium of recent and fossil zoological specimens, rocks, and minerals. "This is not a Museum, but a working establishment, where all are very busy!"—according to the printed notice that first meets the visitor's eye; but there is always a welcome for the Naturalist, and the specimens are far more carefully displayed and more beautifully kept than in many Museums the writer has had the privilege of visiting. In addition to the ordinary routine of business, Prof. Ward is at present engaged upon an unique collection of the skeletons of marine Invertebrata; while his geological partner, Mr. E. E. Howell, is equally absorbed in bringing together an extensive series of Meteorites. The Professor's visit to South America last year resulted in the discovery of several skeletons of the large extinct Edentata, which are now being mounted for the Agassiz Museum at Cambridge; and the large collection of material in the palæontological galleries comprises much that is as yet quite unrepresented in European Museums. Numerous Cretaceous Fishes and Mosasaurians from Kansas, a large series of the well-known fishes of the Green River Shales, and several Chelonian and Mammalian fossils from the Tertiaries of the West, were among the principal Vertebrates the writer observed.

Toronto.

Fossil Vertebrata do not appear to have been much represented in the Museum of the Toronto University. It may, however, be remarked that all the palæontological specimens were in the main building, of which the greater part was destroyed by last year's disastrous fire. The collection will thus require complete renewal.

Ottawa.

In the Canadian capital, closely adjoining the Government grounds, is the small, neatly arranged Museum of the Geological Survey, occupying the same building as the offices of the Surveyors. One comparatively large gallery is devoted to Canadian fossils, arranged in stratigraphical order; and here are conveniently displayed all the type-specimens described in the publications of the Survey. Among lower Vertebrates the fine collection of Devonian Fishes from Scaumenac Bay, made known by Mr. J. F. Whiteaves, F.G.S., is most conspicuous; and in the total absence of all European material for comparison, one cannot but be struck with the success with which the specimens have been determined and interpreted. Mr. Whiteaves' published figures are, for the most part, slightly restored outlines; but the specimens are all in an exquisite state of preservation, while many minute points in their skeletal anatomy (*e.g.* the "lid" of *Bothriolepis*) have only been exposed by a careful removal of the adhering matrix. Several small Palæoniscid fishes from the Lower Carboniferous of New Brunswick are also exhibited; and among the miscellaneous collections in cabinets is a large series of fish-fragments from the Coal-measures of Cape Breton, closely resembling a collection that might be obtained from the shales of almost any British Coal-field. Among recent acquisitions is an interesting small collection of Chimæroid teeth and other fish-remains from a newly-discovered Devonian horizon in Winnipeg, which will shortly be described by Mr. Whiteaves. One case in the public gallery is occupied with numerous fragments of Tertiary Mammalia, also lately received from the N.W. Territories; and these will form the subject of a forthcoming memoir by Prof. E. D. Cope, considerably extending the known range of some of the genera already described from more southern areas. The walls of the Museum are occupied with maps, sections, proof-plates, and several slabs of rock, the latter including among others the well-known footprints of *Sauropus*, from the Millstone Grit of Nova Scotia, described by Sir J. William Dawson.

Montreal.

There are two interesting palæontological collections in Montreal —that of the Natural History Society, and that founded by Sir J. William Dawson, F.R.S., in the Peter Redpath Museum of Mc Gill College. The latter, however, alone comprises any Vertebrates of importance. Here are preserved the remarkable skeletons of Labyrinthodonts discovered by Sir William Dawson in the Carboniferous tree-stumps of the South Joggins; and here, too, are nearly all the fish-remains described or noticed in the "Acadian Geology." The Labyrinthodont fossils are most difficult of determination from the imperfect and scattered nature of the bones; and many of the structures most carefully and beautifully figured in Sir William Dawson's well-known memoirs can only be observed after the closest scrutiny. Among the fish-remains, the type of *Palæoniscus modulus* appears to the present writer to belong to the Scottish Lower Carboniferous genus *Canobius*, as defined by the latest researches; while the supposed remains of *Rhizodus* would in Britain be assigned to its closely related genus *Strepsodus*. Numerous fish-fragments from the Coal-measures of Nova Scotia indicate the occurrence of

Acanthodes, *Rhizodopsis*, *Megalichthys*, *Cœlacanthus*, and *Platysomus*; and among Devonian fishes, there is the unique type-specimen of *Cephalaspis Dawsoni* from Gaspé. Of recently determined acquisitions, the most interesting, perhaps, is a small *Cottus* from the Pleistocene nodule bed of Green's Creek, near Ottawa, described by Sir William Dawson in vol. iv. No. 2, of the "Canadian Record of Science." All the more important of these fossils are beautifully displayed, with complete labels, in small exhibition cases; and the collection is arranged in stratigraphical order on the first floor of the Museum, with the zoological collection in an encircling gallery immediately above.

Quebec.

There is a small Museum in the Laval University, Quebec, under the care of the Abbé Laflamme; but the palæontological collection is insignificant, and the only items of special interest are the relics of the old Huron Indians.

Boston and Cambridge.

The fine Museum of the Boston Society of Natural History comprises a good general European collection of fossils in addition to those of America; but the only Vertebrates of special interest are some well-preserved examples of the Lower Carboniferous Palæoniscid fishes from New Brunswick, and a few representatives of *Ischypterus* and *Dictyopyge* from the black Triassic shales of Connecticut.

In the adjoining University city of Cambridge, however, there is a most extensive collection of fossil Vertebrata in the Agassiz Museum of Comparative Zoology. One of the most striking features of the public galleries in this Museum is the manner in which merely a selection of the more instructive types is exhibited, without any of the overcrowding and bewildering array that characterizes most institutions of a similar nature. The majority of the remains of extinct Vertebrata are thus placed in one of the capacious storerooms; and the collection has accumulated to such an extent that it has been necessary to stow away the specimens, in most cases, upon shelves and in drawers without any definite arrangement. The Mammalia form the only group that has hitherto been investigated in detail, these remains being described by Professors Scott and Osborn, of Princeton; but the fossil Reptiles occupy many cabinets, and the fossil Fishes, to which the writer devoted most of his attention, by kind permission of Prof. A. Agassiz, form a still more extensive series, representing both the Old World and the New. A large number of Cretaceous fish-remains from Kansas are referable to genera and species described by Prof. Cope; and several fishes from the Coal-measures of Ohio evidently represent forms made known in the works of Prof. Newberry. The Wachsmuth collection of American Lower Carboniferous Selachian teeth is also here; while a number of remains of the huge *Dinichthys*, discovered by Mr. Jay Terrell in Ohio, and lately studied by Prof. Newberry, are rivalled only by those in the Museum of Columbia College, New

York. Among miscellaneous European fossils is the type-specimen of *Semionotus Nilssoni*, Ag., from Sweden; and most British and Continental horizons are well represented by typical species. From the Lower Carboniferous of Scotland there is the fine collection of Mr. Thomas Stock; and from the Coal-measures of Yorkshire is a small series collected by Mr. Percy Sladen. One of the Haeberlein Collections furnishes a great number of beautiful fishes from the Bavarian Lithographic Stone; and there are many drawers of Tertiary fishes obtained from various sources. The most precious of all European collections, however, is that of Schultze from the Devonian of the Eifel, which is in many respects unique. In this are preserved the type-specimens of H. von Meyer's *Physichthys Hoeninghausi*, proving that that supposed genus and species is founded upon remains of three distinct genera (*Macropetalichthys*, *Pterichthys*, and *Ptyctodus*); there are also many examples of Schlüter's *Ceraspis*, which are more suggestive of an ally of *Asterolepis* than of a Pteraspidian; and a number of sigmoidal detached teeth are indistinguishable from those of the "intermandibular arch" of *Onychodus*. In the basement of the Museum, Mr. Samuel Garman has the large collection of recent fishes, amphibians, and reptiles under his charge; and here is the original example of the antique Shark, *Chlamydoselache*, described in his well-known memoir.

Yale University, New Haven.

Of the Peabody Museum in Yale University only one wing is as yet erected, and the enormous collections are thus crowded together in an almost inaccessible manner. The Palæontological Department, under the direction of Prof. Marsh, occupies by far the greatest space; for here is preserved not only the well-known collection of the Professor himself, but also that of the present U.S. Geological Survey made under his direction. The former is destined to remain in its present "location," while the latter will be forwarded in instalments to the National Museum, Washington, as the various groups are investigated and described.

Only one public gallery is devoted to the exhibition of the American extinct Vertebrata; and, as in the case of the Cambridge Museum, merely a few prominent types of each great group are selected for representation. The greater portion of the skeleton of a finely-preserved *Mastodon* occupies the first wall-case on the Mammalian side of the gallery; and this is followed by tolerably complete series of bones of various genera and species of Brontotheriidæ and Dinocerata. The skulls and examples of the dentition are especially fine, and all the more massive specimens are mounted upon plaster bases for support. A few small feet illustrate some stages in the history of the Equidæ, though the series is not so complete as an ordinary visitor would desire; and another table-case contains the type-collection of the now well-known birds with teeth, from the Kansas Chalk. Immediately opposite the entrance, spread out upon the floor, are some of the limb-bones, the sacrum, and caudal vertebræ, of the huge *Brontosaurus*, of whose dimensions the reduced published figures can give no adequate idea. The remainder of the bones are placed in one of the store-rooms below, and it is not unlikely that a model of the complete skeleton will be prepared and mounted for the forthcoming World's Fair at Chicago. Many other portions of Dinosaurs, including *Atlantosaurus*, *Morosaurus*, *Stegosaurus*, etc., are arranged in and upon the adjoining wall-cases; and a typical series of the enormous dermal plates and spines of *Stegosaurus* is placed on plaster blocks in one of the table-cases. A large slab from the Cretaceous of Kansas displays the skeleton of a Mosasaurian Reptile in a condition such as is unknown among its European congeners; and a single table-case is devoted to a large series of Teleostean fishes from the Green River Shales of Wyoming.

The nature of the contents of the extensive store-rooms is so well known from the published descriptions and figures of Prof. Marsh, that it is unnecessary to attempt any enumeration. It is only to be regretted that so great a want of space should prevent the materials being arranged in a more accessible manner. All the smaller specimens are contained in wooden trays, piled up from the floor to the roof in long rows, though all carefully labelled according to the Museum Register; while the larger fossils are placed on the floors and shelves wherever there happens to be an available corner. The latest arrivals, as yet untouched, are also there, wrapped up like mummies in encircling strips of linen and old garments. Other specimens are being extricated from the matrix by the skilful masons—the huge horned Dinosaur, with a head six feet long, undergoing this operation at the time of the writer's visit. The artist is at work in another room, where many of his finest drawings adorn the walls; and at present the sifting of fine Laramie material is also in progress, for the recovery of the Mammalian teeth, of which many have been made known by the Professor. Among lower Vertebrates, there is the Redfield Collection of Triassic Fishes; and numerous Cretaceous and Tertiary Fish-remains, as yet almost untouched, are scattered through the trays more especially devoted to Reptilia and Mammalia.

In this Museum, as at Philadelphia, a series of fragments of the Wealden Dinosaurs from Sussex bears witness to the generosity of Dr. Mantell at the time when such remains excited the wonder of naturalists everywhere and were still unknown in the New World; and if our American fellow-workers, out of their present riches, reciprocated this gift in proportion, British palæontologists would already have a fine series of actual specimens for comparison, instead of being compelled to rely entirely upon published descriptions, figures, or casts.

In conclusion, the writer would tender his best thanks to all whose cordial receptions everywhere added so much to the enjoyment of his tour. Even under the most unfavourable circumstances, every facility for study was invariably granted; and where such large collections have accumulated in so short a space of time the difficulty of convenient arrangement is in nearly all cases considerable.

VII.—On a New Form of Spiral in *Spirifera glabra.*

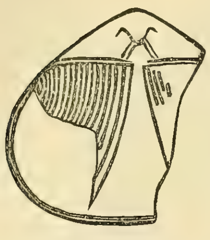
By the Rev. Norman Glass.

In Davidson's Monograph of the British Carboniferous Brachiopoda (1857), p. 60, he gives the following specific characters of *Spirifera glabra* :—" Very variable in shape and proportions ; transversely oval, rarely as long or longer than wide. Valves almost equally convex, with a mesial elevation or fold in the dorsal, and a sinus in the ventral valve. Hinge-line much shorter than the greatest width of the shell ; cardinal angles rounded ; beaks rather approximate, that of the larger or ventral valve prominent, incurved, and of moderate dimensions. A hinge-area in the dorsal valve, that of the ventral one triangular and of moderate dimensions, with its lateral margins more or less sharply defined ; fissure partially covered by a pseudo-deltidium. The mesial fold in the dorsal valve is either slightly and evenly convex, rising gradually from the lateral portions of the valve, or abruptly elevated, with a longitudinal depression along its middle, which is also at times reproduced in the sinus of the ventral one. The spiral appendages are large, and occupy the greater portion of the interior of the shell. Surface of valves in general smooth, but sometimes a few obscure rounded ribs may be observed on their lateral portions."

In a note appended to the above Davidson says :—" I have already had occasion to remark, at p. 81 of my General Introduction, that in p. 139 of his 'Synopsis,' Professor McCoy has described and represented the spiral appendages of *Spirifera* (*Martinia*) *glabra* so small as only to occupy the rostral half of the shell, but this has been proved incorrect; for all specimens obtained in which the spirals were preserved, have shown them to be as large as in any other species of the genus."

With the view of finally deciding this matter of dispute, Davidson, previous to his publication of the Carboniferous Supplement in 1880, desired me to obtain specimens of *Sp. glabra* in order to develop the spirals. I was soon enabled to develop specimens of this species showing the spirals occupying their usual space in the shell, but the specimens thus successfully worked out were comparatively small, and Davidson urgently pressed me if possible to work out some larger specimens. Probably many of your readers are acquainted with the farmhouse and the fields adjoining, which divide the top of the Winnats near Castleton, in Derbyshire, from the high road to Chapel-en-le-Frith. This place is vividly impressed upon my memory in connection with my search for large specimens of *Sp. glabra*—for it was here on a dark winter's night after one of my endeavours that I fell into a snowdrift, and had a long and weary search for the high road, which was so near, but which seemed to me so far. However, my journey, as it proved, was not unsuccessful ; for I had a specimen in my pocket which when developed greatly pleased my friend Dr. Davidson. It was the largest specimen of *Sp. glabra* I had worked out up to that time, and it is represented in Davidson's Carboniferous Supplement, pl. xxxii. fig. 4. This specimen shows the spirals nearly filling the shell, and it was regarded by Davidson as completely disposing of McCoy's attempt to erect *Sp. glabra* into a new genus.

But in June, 1890, I obtained, during a visit to Castleton, a larger specimen of *Sp. glabra* than that just referred to, and of a somewhat different shape, being longer in proportion to its width. A portion of one side of this specimen had been broken away, but in the other portion I succeeded in working out one of the spirals *in situ*, and a small portion of the other spiral, showing, however, its attachment and direction. The shape of the spiral in the new specimen, and the space which it occupies in the shell, is shown in the accompanying sketch.



Spirifera glabra, Martin. Half natural size.

The spiral commences with two or three very large coils which extend nearly the whole length of the interior of the dorsal valve. These large coils are succeeded by others of about half the diameter, which continue with hardly any diminution of size nearly to the end of the spiral. That part of the spiral which is formed by the smaller coils projects outwards towards the lateral margins of the shell from the posterior half of the larger coils—the posterior border of the whole of the spiral being thus nearly straight, and lying close under the hinge-line of the shell. This shape of the spiral, so far as its anterior border is concerned, is quite unique. Out of the thousands of spirals I have seen during my researches amongst British and foreign specimens, I have not met with one of the same shape. It has been abundantly proved by recent investigation in the fossil Brachiopoda that in the various specimens belonging to the same species there is considerable modification as to the shape of the spirals, and that this modification seems to be governed in the majority of instances by the variation in the size and shape of the shell (see the descriptions and figures of my preparations of *Spirifera striata* and *Atrypa reticularis* in Davidson's Carboniferous and Silurian Supplements)—so that there is nothing abnormal in the occurrence of differently shaped spirals in a newly developed specimen of *Sp. glabra*.

This larger specimen of *Sp. glabra* which I have now developed would have greatly interested Dr. Davidson because showing how the mistake of McCoy might naturally have arisen. As the first two or three coils of each spiral are prolonged nearly to the anterior margin of the shell, the spirals cannot properly be described as being "so small as only to occupy the rostral half of the shell"; whilst on the other hand it is evident that through the greater part of each spiral being close to the posterior border of the dorsal valve, there remains a large portion of space in the shell which the spirals do not occupy. If, therefore, in the specimen seen by McCoy, the prolongation of the first two or three coils of each spiral towards the anterior margin of the shell, was either not exposed, or broken away at the time of deposition, the conclusion at which he arrived was a very natural one, though not in accordance with the results of further investigation.

VIII.—Notes on some Observed Rates of Weathering of Limestones.

By J. G. Goodchild, F.G.S., of H.M. Geol. Survey,
Lecturer on Geology at the Heriot Watt College.

In the Geol. Mag. for July, 1875, p. 326, the writer of the present note gave some data bearing upon the rate of weathering of certain limestones of the Lower Carboniferous Series, deduced from the observed extent of waste that had affected some dated tombstones in Kirkby Stephen Churchyard. The series of observations of which that formed a part were suggested several years previously by the fact that many of the rough blocks of limestone used for walling in that neighbourhood had evidently suffered considerable waste since the erection of the walls, and this especially on the upper and outer surfaces of the stones referred to. In a few of these cases (as well as in many other cases observed since) it was perfectly evident that, since the coping stones had been placed in their present positions, the waste of the limestone by atmospheric causes had proceeded to at least as much as a quarter of an inch. This was evident from the fact that thin, delicate, fragments of Corals, Brachiopods, Encrinites, etc., were left standing out in sharp relief to that extent above the general surface of the adjoining limestone matrix. There could be no doubt about the fact itself, or about its significance; but many inquiries failed to bring to light any reliable information regarding the precise date when the stones were first quarried. For aught we could say to the contrary, any one, or all, of the stones might have been employed for building purposes for hundreds of years previously; although that was hardly likely.

Similar phenomena were observed along the walls of the North Western Railway between Teba and Shap; but regarding the earlier history of these no reliable information could be obtained.

With the tombstones above referred to the case was different. Here we had stones that had been carved out of solid, unweathered limestone at a given date recorded upon the tombstone itself, and side by side with the date was given, by the hand of Nature, a fairly exact record of the amount of limestone that had been carried away in solution from the general surface of each of the tombstones in question. The mean of several observations gave as the rate of solution about one inch in five hundred years (Geol. Mag. 1875, p. 326). These observations were made upon tombstones standing erect, and therefore in the least favourable position for the kind of erosion under notice. Where similar stones were lying flat, waste by atmospheric causes almost certainly proceeded at a higher rate: but no dated tombstones in this position could then be found. In the estimate just given no account was taken of the fact that other planes of easy solution were evidently in process of development. Some of these were following the original planes of deposition of the rock; others tended to work in along the bate, or those obscure planes of separation along which direction, as masons know, the rock will dress more readily than along others. Other planes again, artificially induced, were being etched parallel to the dressed surface, as Prof. Judd had shown to be the case with the worked flints employed for outdoor masonry. Altogether, a careful study of the phenomena of erosion presented by these dated tombstones, pointed to the conclusion that the rate of waste now in progress will, in a few years, be very greatly accelerated by the multiplication of the surfaces presented to the denuding agents. We might, therefore, safely assign to this rock a rate of destruction treble or quadruple that given in the estimate above. Weathering soon reveals the existence of the 'bate' in limestones, and detaches flake after flake, parallel to the joint planes, with comparative rapidity; almost as if the bate or grain of the rock represented some kind of cleavage affecting the whole mass of the limestone. On the vertical face of limestone scars, or in the same position in limestone waterfalls, it is very evident that the chief waste of the rock is effected by this constant flaking off of thin slices of weathered rock detached by weathering along the bate of the rock. The flakes fall, expose an inner face to the action of the weather, and are themselves soon dissolved and carried out of sight.

There is, of course, very considerable difference in the rate at which different limestones tend to waste before atmospheric agencies. Those which contain an unusual percentage of argillaceous matter appear to waste at the highest rate; and this is the more especially the case if the rock in question has been more or less dolomitized, as have many of the Carboniferous Limestones that have formerly received magnesian infiltrations from the New Red Rocks—the commonest source of dolomitization in Britain. At the other extreme (so far as the writer's own observations go) stand the compact, well-bedded, limestones that include much bituminous matter in their composition. But the rate of waste of bituminous limestones is by no means a low one under favourable circumstances, as the following observations will show:—About forty years ago a very hard, compact, bituminous limestone, belonging to the Yoredale Series, had been broken up for road metal, on a cart road leading to a fell-side coal mine near Tailbrig, Westmoreland. After a time, the coal mine, and consequently the road leading to it, ceased to be used. So the road was left for about twenty-five years. The nature of the surface in the higher part of the road favoured the passage over it of thin sheets of surface-water, charged more or less with compounds derived from the decomposing vegetable matter of the moorlands above. After the interval mentioned above had elapsed, the present writer happened to notice that the limestone "macadam" had evidently undergone many changes in consequence of its prolonged exposure. The surface of the whilom angular fragments of limestone was etched and corroded into irregular pits as if the rock had been steeped in weak acid. The characteristic glaze, due to the redeposition of thin films of carbonate of lime, imparted a curious artificial appearance to the stones. But the most remarkable feature was the projection of delicate portions of corals and other organisms in sharp and high relief above the general surface of the weathered stones. It was perfectly evident that, since the road had ceased to be used as a cart road, the surface-waters had etched away the limestone to a depth of at least one-sixth of an inch, leaving the sharp edges of the fossils standing out to that extent in relief, to testify to the quantity of the surrounding matrix that had been dissolved and carried away in the mean time. One could not feel sure that the slender, delicate, edges of the projecting fossils afforded correct data for determining the original surface exposed; but assuming that they did so, and that no more had been removed than we can now estimate from these data, the present state of the stones in question proves that even bituminous limestone may be dissolved away by atmospheric agencies at the rate of one inch in two hundred and fifty years. Here again we have to take further into account the accelerated waste consequent upon the development of additional planes of solution along the bedding and the bate.

Another case in which an approximate estimate of the quantity of limestone removed by atmospheric causes in a known time occurred near Penrith several years ago. In one of the cuttings on the Keswick Railway just south-west of Penrith, a bed of limestone belonging to the Yoredale Series was bared of glacial drift for a short distance. When newly exposed, the limestone presented the usual appearance of a striated and smoothly-polished surface, without a trace of any asperities due to projecting fossils. An exposure to the weather for a period of only ten years sufficed not only to roughen the surface of the limestone, but to lower the general surface of the rock to such an extent that some of the more durable fossils were left standing about one-thirtieth of an inch in relief. In other words the limestone was wasting away along that surface alone at the rate of one inch in three hundred years. In the present case the water affecting the stone must have been almost entirely free from any admixture derived from decomposing vegetable matter, and the rock surface must have remained dry except during showers. [At Blenco Station, just beyond, a slab of sandstone beautifully glaciated has been exposed to precisely the same conditions for about 25 years; but it shows no signs whatever of having undergone any waste in the mean time. The contrast between the behaviour of the two kinds of rock in this, as in the majority of the other cases that have come under my notice, is most striking and instructive.]

Within the last month (August, 1890), another illustration of an equally instructive nature has been observed. Twelve years ago the new railway between Leyburn and Hawes, in Wensleydale, was in process of construction, and the contractors naturally took advantage, wherever they could, of any quarries of building stone suitable for their requirements. When the station at Askrigg was to be built, limestone was quarried close by in Millgill, not far from Millgill Fors. The rock is a slightly-argillaceous limestone, generally crowded with fossils. This was roughly dressed into shape, and finally chiselled along marginal fillets when the rock was built up as the quoins of the station and its surrounding buildings. I had occasion to stay a few hours at the station lately, and then took careful note of the condition of the stone at that time. After an exposure of twelve years the dressed surface of the stone in question is everywhere rough to the feel; and the general surface has been lowered by atmospheric waste in the mean time to such an extent that some of the more durable fragments of fossils remain in relief to about a twentieth of an inch. Assuming that the upper surface of the fossils represents the original dressed surface of the limestone quoins, then it is evident that the limestone has already wasted away at the rate of one inch in two hundred and forty years. This, however, is only the beginning of it: when the weather has eaten into the bedding planes and the bate of the rock, then the rate of waste will certainly be proportionate to the increased surface exposed to the attacks of the weather.

We have, in these facts, some kind of measure of the initial rate at which limestone is wasted along any given surface. Briefly summarized the facts are these:—

The Kirkby Stephen tombstones	had weathered	at the rate of	1	inch in	500	years.
The Tailbrig "macadam"	,,	,,	1	,,	250	,,
The Penrith limestone	,,	,,	1	,,	300	,,
The Askrigg limestone	,,	,,	1	,,	240	,,

A rough average based upon these observed facts would indicate as a kind of general rate of waste about one inch in three hundred years: that, of course, refers to waste along one plane, and does not take into account the greatly accelerated waste consequent upon the rock being attacked simultaneously along many different planes. I believe we shall not err greatly in assigning at least double the rate of erosion to limestone generally.

The bearing of these facts upon some larger phenomena of denudation will be indicated in a subsequent communication.

NOTICES OF MEMOIRS.

British Association for the Advancement of Science. Leeds, September 4th to 10th, 1890.

List of Titles of Papers read in Section C, Geology.

Professor A. H. Green, M.A., F.R.S., President.

The President's Address. (See p. 475.)

Professor O. C. Marsh.—On the gigantic *Ceratopsidæ* (or horned Dinosaurs) of North America.

B. Holgate.—The Carboniferous Strata of Leeds and its immediate Suburbs.

B. Holgate.—Some Physical Properties of the Coals of the Leeds District.

G. W. Lamplugh.—On the Boulders and Glaciated Rock-surfaces of the Yorkshire Coast.

G. W. Lamplugh.—East Yorkshire during the Glacial Period.

G. W. Lamplugh.—Report on an Ancient Sea Beach near Bridlington.

J. F. Walker.—On Liassic Sections near Bridport.

T. De la Touche.—On the Sounds known as the "Barisúl Guns," occurring in the Gangetic Delta.

T. Tate.—On the so-called "Ingleton Granite."

W. A. E. Ussher.—The Devonian Rocks as described in De la Beche's Report, Interpreted in Accordance with Recent Researches.

Dr. H. Hicks.—On Pre-Cambrian Rocks occurring as fragments in the Cambrian Conglomerates in Britain.

Dr. H. Hicks.—The Effects produced by Earth-movements on the Pre-Cambrian and Lower Palæozoic Rocks in some sections in Wales and Shropshire.

C. S. Wilkinson.—On the Mineral Resources of New South Wales.

Dr. H. W. Crosskey.—Report on Erratic Blocks.

P. F. Kendall.—The Glacial Phenomena of the Isle of Man.

G. W. Lamplugh.—On the Speeton Clays and their Equivalents in Lincolnshire.

H. G. Seeley.—On the Neural Arch of the Vertebræ in the Ichthyosauria.

W. Brindley.—The Marbles and other Ornamental Rocks of the Mediterranean.

Dr. Tempest Anderson.—On the Supposed Volcanic Eruption of Cape Reykjanæs, Iceland, in 1887.

W. Cash.—On a new Lepidodendron from the Halifax Hard Bed.

J. R. Dakyns.—On the Changes of the Lower Carboniferous Rocks in Yorkshire, from South to North.

Dr. J. Crawford.—Human Footprints in Recent Volcanic Mud in Nicaragua.

Dr. J. Crawford.—On the Geology of Nicaragua.

J. C. Antrobus and *Dr. F. H. Hatch.*—Preliminary Note on the Composition and Origin of the Cheshire Boulders.

Dr. F. H. Hatch.—On some West Yorkshire Mica-Trap Dykes.

T. Tate.—Note on Phillips' Dyke, Ingleton.

Dr. H. J. Johnston-Lavis.—Report on the Volcanic Phenomena of Vesuvius.

A. R. Hunt.—On the Origin of Saline Inclusions in the Crystalline Rocks of Dartmoor.

J. Bickerton Morgan.—On the Base of the Silurian in North-east Montgomeryshire.

W. W. Watts.—Geology of the Long Mountain on the Welsh Borders.

Rev. E. Jones.—The Exploration of Elbolton Cave.

Dr. A. Irving.—Physical Studies of an ancient Estuary.

C. E. De Rance.—Report on the Circulation of Underground Waters.

Professor T. Rupert Jones.—Report upon the Fossil Phyllopoda of the Palæozoic Rocks.

G. R. Vine.—Report on the Cretaceous Polyzoa.

W. Whitaker.—Suggestions on Sites for Coal-search in the South-east of England.

Dr. P. H. Carpenter.—On some points in the Morphology of the Cystides.
Professor Silvanus Thompson.—On the Source of the River Aire.
O. W. Jeffs.—Report on Geological Photographs.
J. W. Davis.—Fossil Fish of the West-Riding Coal-Field.
A. Smith Woodward.—On the Discovery of a Jurassic Fish-Fauna in the Hawkesbury Beds of New South Wales.
A. Smith Woodward.—Communications on behalf of *Professor Anton Fritsch* (of Prague). Restorations of the Palæozoic Elasmobranchs, *Pleuracanthus* and *Xenacanthus.*
J. E. Marr.—Report on the Registration of Type-Specimens.
A. Bell.—Report on the "Manure-Gravels" of Wexford.
J. L. Lobley.—On the Origin of Gold.
R. G. M. Browne.—On the Historic Evidence as to the Change of Sea-level off the South Coast of England.
T. Hart.—Notes on Volcanic Paroxysms.

Papers read in other Sections bearing on Geology and Palæontology :—

Prof. O. C. Marsh.—Cretaceous Mammals of North America.
Prof. J. Milne.—Report of the Committee on the Volcanic and Seismological Phenomena of Japan.
Dr. Tempest Anderson and *Dr. Johnston-Lavis.*—A Visit to the Skapten District of Iceland.

REVIEWS.

I.—Geological Survey of Western Australia. Annual General Report for 1888–1889. By Harry Page Woodward, F.G.S., etc., Government Geologist. 8vo. pp. 60. (Perth, W.A., 1890.)

THE geologist in Western Australia has a fine field for original observations, for there is an area of upwards of a million square miles in which up to the end of 1887 very little had been done in the way of a systematic Geological Survey. Hitherto scarce a dozen geologists have plied their hammers in this vast territory, although some of them have done good and detailed work over limited tracts, and have forwarded collections of fossils to England for description. Many years must yet elapse before even the leading geological features of Western Australia can be marked out; but during the years 1888 and 1889 a great deal has been accomplished by the Government Geologist, Mr. Harry P. Woodward, whose Report is now before us. A Geological Surveyor in Britain would be astounded at the idea of mapping 64,000 and more square miles in one year; but such is the record of work done by this energetic geologist in Western Australia, and it is easy to calculate, in a rough way, the time that might be occupied in completing a geological sketch-map of the entire Colony.

The country has only been "settled" for about 200 miles inland, whereas it is 1450 miles in its greatest length and 850 miles in breadth. Mr. Harry Woodward, however, hopes to have examined most of the settled country by the end of the present year, when he proposes to issue a geological map of the Colony, filling in such information concerning the interior as can be gained from the reports and maps of explorers. This will be a most valuable basis for further work, and especially useful to others interested in the subject.

In the present Report we find an historical account of the work of the previous observers, and detailed summaries of the observations made by the author, during his first two years of office. What will be most interesting to our readers is the general account given of the rocks at present known in Western Australia, and these are tabulated as follows:—

SEDIMENTARY ROCKS.

Cænozoic.	Quaternary.	Recent (Holocene).	Alluvium, River Gravels and Estuarine deposits, Sand Dunes, Raised Beaches, etc.
		Pleistocene.	Ancient River Gravels, etc. Lower Estuarine deposits, shelly limestones and sandstones of the coast.
	Tertiary.	Pliocene.	Ferruginous sandstones and variegated clays.
		Eocene.	Coralline and chalky limestones with flints, calcareous and ferruginous sandstones and grits.
Mesozoic or Secondary.		Cretaceous.	Chalky limestones with flints, sand, ferruginous sandstones and limestones, ferruginous nodular clay-stones, sands, clays and mudstones.
		Jurassic.	*Oolites.*—Oolitic limestone, clay ironstone, ferruginous sandstone, grits and conglomerates. *Lias.*—Ferruginous and variegated limestones, clays and ironstones.
Palæozoic or Primary.		Carboniferous.	Sandstones, grits, conglomerates and ironstone, limestones, mudstones, micaceous clays and shales, with iron-pyrites, gypsum, and coal-seams.
		Devonian.	Shales, indurated slates, limestones, coarse grits, and conglomerates.
		Silurian and Metamorphic.	Clay-slate, limestones, marble, dolomite, sandstones, quartzites, and conglomerates.
Azoic?		Archæan (Metamorphic).	Slates, schists, serpentine, quartzite, gneiss, granitoid, and garnet rocks.

IGNEOUS ROCKS.

Volcanic.	Basalt, Dolerite.
Plutonic.	Felstone, diorite (greenstone), syenite, granite. porphyry, amygdaloid.

This is a goodly list of formations, while the sequence of strata and their striking correspondence in general lithological character with some of the European equivalents, is remarkable. It is stated that the next Annual Report will, if possible, contain a list of the fossils of the country.

The presence of Jurassic and Cretaceous rocks was first made known by Mr. F. T. Gregory in 1861, and large additions to our knowledge of the Oolitic and Liassic fossils were published by

Charles Moore in 1870.[1] Moore then remarked on the striking similarity between the matrix of the Australian specimens and the Lower Oolitic rocks of England with which he was so familiar; and he recognized twenty species of fossils as common to the two countries.

A few of the Carboniferous and Devonian fossils from Western Australia, lately described in the GEOLOGICAL MAGAZINE (for the present year) by Mr. A. H. Foord, Prof. Nicholson, and Dr. Hinde, are identified as belonging to European species; other Carboniferous forms were also described by Mr. Hudleston in 1883,[2] at which date there was no proof of the presence of Devonian strata in Western Australia. Indeed, in his Report, Mr. Woodward states that no fossils are known from the Devonian rocks, but we must not anticipate his remarks on the species so recently described from rocks of this age in the Colony. The subject of the sequence of organic remains in a tract so distant from us is of great interest, and especially when we find many facts corresponding with those known in Europe. The absolute identity of species in the two areas may be questioned by some specialists: but minute differences cannot affect the general question, although it is important to note them. What is of first importance is that the stratigraphical sequence in Australia be made clear with the aid of sections, and we trust the Government Geologist will supply these in future Reports. It will also be interesting to learn more of the Serpentine, which is placed among the Archæan (Metamorphic) rocks.

The subject that is of most concern to the Colonists is that of the Mineral Wealth, and this necessarily has occupied the chief share of Mr. Woodward's attention. Gold, and ores of Lead, Copper, and Tin, are to be had in profitable quantities, but the difficulties of access, the scarcity of water in some areas, and the cost of labour, have combined to arrest enterprise. There is Iron-ore "enough to supply the whole world," and there are ores of Antimony and Manganese, as well as large and very pure deposits of Kaolin. The Coal at present found appears to be of inferior character, and "where wood is so abundant and always close at hand, there is no demand for any, except a first-class steam coal." It is stated, however, that "Coal has recently been found at Wyndham, but though the sample sent down was of very fair quality, the size and extent of the seams have not yet been tested."

With regard to the Soils, it is observed that they are as good and as varied as in any part of the world, but large tracts of the best land are still heavily timbered. Some interesting remarks are made on the work of the White Ants, whose nests contain so much iron that "when a tree has been burnt in which they have built a nest, there will be found at its base a mass of iron clinker, looking just as if it had come out of a furnace."

It is interesting to learn that the south-west coast is rapidly rising, and indeed "many old colonists remember when land at Fremantle, now quite above the water-level, used daily to be covered by the tide."

[1] Q.J.G.S. vol. xxvi. pp. 229, 231. [2] *Ibid.* vol. xxxix. p. 582.

II.—Geological Survey of India. Memoirs, vol. xxiv. part 2, Physical Geology of the Sub-Himalaya of Garhwal and Kumaun. By C. S. Middlemiss, B.A. (Cantab).

As bearing on a question so much discussed as is that of the origin and growth of mountains, it seems strange that some very definite results published by the Geological Survey of India so long ago as 1864 regarding the greatest mountains in the world should have been generally ignored. It is to be hoped that this small geological scandal may be arrested by the latest publication of that Survey, here under notice. The ground is continuous with that to the west of the Ganges, described by me in Vol. III. of the Memoirs; and Mr. Middlemiss begins by quoting some recent instances of the neglect aforesaid, whereby absurdly erroneous statements are still made regarding the part taken by the Tertiary (Siwalik) rocks in the Himalayan mountain-system, although the correct view of that relation had been quite explicitly set forth by me, as has now been verified by more detailed work. I have humbly to plead guilty to the want of lucidity complained of by Mr. Middlemiss; the particular conclusions arrived at were indeed categorically stated,[1] but it is more or less excusable that these should have taken no hold when the evidence for them had to be painfully extracted from a maze of conflicting considerations. In the present Memoir it is duly admitted that when I took it up, the stratigraphy was practically unknown, and that I had to work with very imperfect maps on a small scale—the old edition of the Indian Atlas sheets; while the new work was started from a good base of information, and with the admirable large-scale maps of the new Forest Survey. Mr. Middlemiss has done full justice to these more favourable conditions. His work is given with a fulness of detail and a clearness of exposition that leave little to be desired.

The general result admits of being stated in a sentence: that, notwithstanding more or less of modification by reverse faulting, the main boundary of the sub-Himalayan zone with the higher mountains, as well as the several lines of contact between newer and older deposits within that zone, are primarily and approximately original limits of deposition. This is what I have maintained since 1864. The proof positive of such a relation is of course the production of a section showing actual original contact of newer upon or against older deposits at the boundary in question. Such a section I did present[2] of Siwalik conglomerates in original contact with bottom Nahan beds at the boundary near Tib, south of Nahan. The isolated remnant of the newer rock was indeed only a shred; still it was enough to swear by, if genuine, as I enthusiastically took it to be. Many years later, in 1881, Mr. R. D. Oldham called me to account upon this point; and on revisiting the spot with him, I admitted that the patches of gravel which I had fondly taken to be Siwalik more probably belonged to the recent high-level gravels.

[1] *Loc. cit.* p. 174. [2] *Loc. cit.* p. 108.

I immediately published[1] a retractation of my error; maintaining at the same time, upon what I held to be ample collateral evidence, that my view of the boundary was still essentially correct. With such an awful warning before him, Mr. Middlemiss was not likely to fall into the same mistake; indeed, the number and extent of the sections he describes and figures, from widely distant localities, showing original unconformable contact of this kind, leave no room for such a supposition. At other points along the same continuous boundary the contact is of the type so usual in this region—a steep plane with the older rocks overhanging the newer, sometimes in apparent conformable sequence and each in normal order, the middle limb of the folded flexure having been removed by overthrust. It is quite clear that a common phase of this action may be a complete simulation of a fault, normal or reversed, by the simple tilting of a denuded face of the upper limb of the flexure after the deposition of newer rocks against it, instances of which are given in Nos. I. and II. of the sections under notice. The fault at Jirinjala in Section V. seems uncalled for. Altogether, to speak of those boundaries, without qualification, as faults, is to ignore their primary and most interesting character. When in a continuous sequence of strata a folded flexure occurs, with fracture and overthrust, the plane of contact is a fault in the full sense of the word; but to describe the main boundary of the sub-Himalayan zone as a great fault is to open the door for the very blunder that Mr. Middlemiss has deplored. This is quite an ancient bone of contention with me.[2] I had expected to find some reflections by Mr. Middlemiss on the lines suggested by Mr. R. D. Oldham, in 1885,[3] that under the conditions supposed there must have been for every stage a fringing zone of boulder deposits, like the modern bhábar, of which the outer Siwalik conglomerates are the next preceding representative; and, that judging by analogy, the unrepresented bhábar deposits corresponding to the Nahan sandstone must have extended about twelve miles north of the present main boundary.

The "one minor discrepancy" noticed at page 111 between my work and his own, regarding a fourth possible sub-Himalayan group, disappears at once with the recognition of the Siwalik sand-rock on the north of the Kearda-Dehra dún. Again, at page 124, an alternative view is mistaken for the one I finally adopted—that elsewhere in the neighbourhood there is completely conformable sequence between strata that are strongly discordant along the lines of upheaval. At page 32, in his remarks on the main boundary, Mr. Middlemiss may have forgotten that at one spot, not in his area, where the Satlej crosses that boundary, the Subathu beds of the Sirmur area pass continuously, by a narrow band, into the sub-Himalayan zone, and there the Nummulitic beds and what may be Nahans are in normal succession. In that direction, in Kangra and Jamu, a much fuller subdivision of the sub-Himalayan system

[1] Records, vol. xiv. p. 169.
[2] Geol. Mag. 1869, p. 341; 1870, p. 473.
[3] Records, vol. xviii. p. 110.

will, I believe, have to be made out, as suggested in the Manual (p. 554). It is all very fine to object to the "torment" of conflicting hypotheses (p. 110), but for my part I never could find comfort in an artificial paradise.

There is one point that calls for more explicit notice. In my Memoir (p. 174) I recorded a conclusion of some general interest: that "The Krol group [*i.e.* the massive limestone], the youngest of the older rocks, though greatly denuded, had undergone little or no contortion along the outer zone of the mountain area, prior to the formation of the Subathu Nummulitic rocks." The statement was based upon the section at Subathu, where, on both sides of a steep synclinal fold of considerable width, the characteristic bottom bed of the Tertiary series occurs with complete parallelism upon slaty flags of the Infra-Krol horizon. In the Manual (p. 569) I re-affirmed the statement, confirming it in part by evidence from the sub-Himalayan zone in Jamu, where the same typical bottom Tertiaries regularly overlie the massive limestone. I thus laid further stress upon the Subathu section, as proving that elevation with great denudation had taken place much earlier in the eastern area. The affirmations as to denudation and contortion are distinct, and should be severally maintained or refuted. The geologist should rarely indulge in the word "impossible"; but I do assert it as to me inconceivable that the contact relation at Subathu could have been brought about unless the Krol group had been removed by denudation prior to the deposition of the Subathu beds, and unless the Infra-Krol beds had then been unplicated. In the immediate neighbourhood, sections abound showing the usual crushed and confused contact. Until that section at Subathu is specifically disposed of, I must hold to it.

Mr. Middlemiss endeavours gently to extricate me from this position. He says (p. 4) that in repeating it in the Manual I unfortunately trusted largely to the sections in Jamu; but on the face of it this is wrong, for half of my affirmation rests solely on the Subathu section. To this section Mr. Middlemiss only refers in a footnote; and it does not seem certain whether he had ever seen it. It does not appear as if Mr. Middlemiss were quite certain of this feature in his own ground. In Section VI. the Subathu beds and the underlying fossiliferous Tal beds are in regular sequence upon the massive limestone, while in Section IX. the two former, without the limestone, rest in rough parallelism on the old slates, without faulting; and his facts in favour of an earlier plication of the Himalayan rocks are only quotations of wholesale differences of strikes in that region. Of course the presumption seemed all in favour of such earlier disturbance with plication of the older rocks; but I thought it right to point out that the most particular facts in hand would point the other way, in the direction of an origin in continental elevation by bossellement as suggested by De Beaumont. Such references to elementary theories give point to stray remarks, and by no means imply the advocacy of the developments that may have grown out of the said theories.

The general remarks upon mountain formation in Mr. Middlemiss's concluding chapter are the least satisfactory part of his work. Mr. Mellard Reade's book on "The Origin of Mountain Ranges" is taken as the fulcrum of discussion; and some effective execution is done in the way of demolishing errors of "fact," but the *reductio ad absurdum* of the "principle" involved is not complete. Some caution might have been suggested by the knowledge that Babbage and Herschell were the promoters of the said principle in this cause, for such men were not likely to commit absurd blunders in the elements of mechanical physics. The key sentence in Mr. Middlemiss's argument (p. 131) is, to say the least of it, obscure; that "great sedimentation of this kind can only take place by concomitant sinking of the sea-bottom; so that the rise of the isogeotherms being interpreted means merely the sinking of the floor on which the deposits were laid down." It certainly does mean that much; but the form of expression is incomplete or even misleading, for the process is not wholly a rising of the isogeotherms, but also a sinking of the strata into zones of higher temperature with the inevitable concomitant expansion, which through tangential resistance must (unless some line of less resistance is already established) result in the plication with elevation of the strata concerned, to which action the origin of true mountains is plausibly attributed by the theory in question. Mr. Middlemiss seems to ignore the significant distinction between continental elevation and "true mountains." The total rejection of the Babbage-Herschell principle is the more strange as this starts from the same point—the "condition of approximate hydrostatical equilibrium" of the earth's crust—as does the discussion of the same question by Mr. Fisher, of which so much approval is deservedly expressed. It is not unlikely that the subsidence of the plains' deposits into regions of higher temperature may be a factor in the continued rise and compression of the sub-Himalayan zone, which Mr. Middlemiss emphasizes as if it had been denied. It is clear, too, that the rise extends to the whole of the outer Himalaya, else the transverse river gorges would have become lake-basins, as has occurred in the Alps. But Mr. Middlemiss does not sufficiently keep in mind that the mountains he refers to are but the southern face of the Himalayan massif, the crest of which must, as indicated by the drainage lines,[1] have been far to the north of the present range of greatest elevations. The decadence suggested by me was assigned to that central region. The unfortunate expression "life history," as applied to things that have no life, might have helped him here as it seems to have confused him elsewhere: for a man's brain may mature while his limbs go to the bad, or *vice versa*. Rhetoric is an unsafe and unsavoury ingredient in scientific work. Henry B. Medlicott.

[1] Manual, p. 675.

REPORTS AND PROCEEDINGS.

SIXTIETH ANNUAL MEETING OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,

LEEDS, 1890.

ADDRESS TO THE GEOLOGICAL SECTION OF THE BRITISH ASSOCIATION. By Professor A. H. GREEN, M.A., F.R.S., of the University of Oxford, President of the Section, September 4th, 1890.

THE truth must be told; and this obliges me to confess that my contributions to our stock of geological knowledge, never very numerous, have of late years been conspicuously few, and so I have nothing to bring before the Geological Section that can lay any claim to be the result of original research.

In fact, nearly all my time during the last fifteen years has been taken up in teaching. This has led me to think a good deal about the value of geology as an educational instrument, and how its study compares with that of other branches of learning in its capability of giving sinew and fibre to the mind, and I have to ask you to listen to an exposition of the notions that have for a long time been taking shape bit by bit in my mind on this subject.

I am not going to enter into the question, handled repeatedly and by this time pretty well thrashed out, of the relative value of natural science, literature, and mathematics as a means of educational discipline; for no one who is lucky enough to know a little of all three, will deny that each has an importance of its own and its own special place in a full and perfect curriculum. The question which is the most valuable of the three I decline to entertain, on the broad general ground that "comparisons are odorous," and for the special reason that the answer must depend on the constitution of the mind that is to be disciplined. I might quite as reasonably attempt to lay down that a certain diet which suits my constitution and mode of life, must agree equally well with all that hear me.

I need scarcely say that nothing would induce me, if it could possibly be helped, to say one word that might tend to disparage the pursuit to which we are all so deeply attached. But I cannot shut my eyes to the fact that, when geology is to be used as a means of education, there are certain attendant risks that need to be carefully and watchfully guarded against.

Geologists, and I do not pretend myself to be any better than the rest of them, are in danger continually of becoming loose reasoners. I have often had occasion to feel this, and I recall a scene which brought it home to me most forcibly. At a gathering, where several of our best English geologists were present, the question of the causes of changes of climate was under discussion. The explanation which found most favour was a change of the position of the axis of rotation within the earth itself; and this, it was suggested, might have been brought about by the upheaval of great bodies of continental and mountainous land where none now exist, and an accompanying depression of the existing continents or parts of them. That such a redistribution of the heavier material of the earth would result in some shifting of the axis of rotation admits of no doubt. The important question is, How much? What degree of rearrangement of land and sea would be needed to produce a shift of the amount required? It is purely a question of figures, and the necessary calculations can be made only by a mathematician. I ventured to suggest that some one who could work out the sum should be consulted before a final decision was arrived at, for I knew perfectly well that not one of the company present could do it. But if I say that my advice met with scant approval, I should represent very inadequately the lack of support I met with. The bulk of those present seemed quite content with the vague feeling that the thing could be done in the way suggested, and there was a general air of indifference as to whether the hypothesis would stand the test of numerical verification or not.

I could bring many other similar instances which seem to me to justify the charge I have ventured to make; but it will be more useful to inquire what it is that has led to a failing, which, if it really exist, must be a source of regret to the whole brotherhood of hammerers.

The reason, I think, is not far to seek. The imperfection of the Geological Record is a phrase as true as it is hackneyed. No more striking instance of its correctness can be found than that furnished by the well-known Mammalian jaws from the Stonesfield slate. The first of these was unearthed about 1764; others, to the number of some nine, between then and 1818. The rock in which these precious relics of the beginning of Mammalian life occur has been quarried without intermission ever since; it has been ransacked by geologists and collectors without number; many of the quarrymen know a jaw when they see it, and are keenly alive to the market value of a specimen; but not more than six or seven of these prized and eagerly-sought-after fossils have turned up during the last seventy years.

Then again how many of the geological facts which we gather from observation admit of diverse explanation. Take the case of *Eozoon Canadense.* Here we have structures which some of the highest authorities on the Foraminifera assure us are the remains of an organism belonging to that order; other naturalists, equally entitled to a hearing, will have it that these structures are purely mineral aggregates simulating organic forms. And hereby hangs the question whether the limestones in which the problematical fossil occurs are organic, or formed in some other and perhaps scarcely explicable way.

And this after all is only one of the countless uncertainties that crowd the whole subject of invertebrate palæontology. In what a feeble light have we constantly to grope our way when we attempt the naming of fossil Conchifers for instance. The two species *Gryphæa dilatata* and *G. bilobata* furnish an illustration. Marked forms are clearly separable, but it is easy to obtain a suite of specimens, even from the Callovian of which the second species is said to be specially characteristic, showing a gradual passage from one form into the other. And over and again the distinctions relied upon for the discrimination of species must be pronounced far-fetched and shadowy, and are, it is to be feared, often based upon points which are of slender value for classificatory purposes. In the case of fossil plants the last statement is notoriously true, and yet we are continually supplied with long lists of species which every botanist knows to be words and nothing more, and zonal divisions are based upon these bogus species and conclusions drawn from them.

It is from data such as have been instanced, scrappy to the last degree, or from facts capable of being interpreted in more than one way, or from determinations shrouded in mist and obscurity, that we geologists have in a large number of cases to draw our conclusions. Inferences based on such incomplete and shaky foundations must necessarily be very largely hypothetical. That this is the character of a great portion of the conclusions of geology we are all ready enough to allow with our tongue—nay, even to lay stress upon the fact with penned or spoken emphasis. But it is open to question whether this homage at the shrine of logic is in many cases anything better than lip-service; whether we take sufficiently to heart the meaning of our protestations, and are always as alive as our words would imply to the real nature of our inferences.

A novice in trade, scrupulously honest, even morbidly conscientious to begin with, if he lives among those who habitually use false scales, runs imminent risk of having his sense of integrity unconsciously blunted and his moral standard insensibly lowered. A similar danger besets the man whose life is occupied in deducing tentative results from imperfectly ascertained facts. The living, day by day, face to face with approximation and conjecture, must tend to breed an indifference to accuracy and certainty, and to abate that caution and that wholesome suspicion which make the wary reasoner look well to his foundations, and resolutely refuse to sanction any superstructures, however pleasing to the eye, unless they are firmly and securely based.

If I am right in thinking that the mental health of the geologist of matured experience and full-grown powers is liable to a disorder of the kind I have indicated, how much greater must the risk be in the case of a youth, in whom the reasoning faculty is only beginning to be developed, when he approaches the study of geology! And does it not seem at first sight that that study could scarcely be used with safety as a tool to shape his mind, and so train his bent that he shall never even have a wish to turn aside either to the right hand or to the left from the strait path that leads through the domain of sound logic?

That it is hazardous, and that evil may result from an incautious use of geology as an educational tool, I entertain no doubt. The same may indeed be said of many other subjects, but I feel that it is specially true in the case of geology. But I should be guilty of that very haste in drawing conclusions against which I am raising a warning word, if I therefore inferred that geology can find no place in the educational curriculum.

To be forewarned is a proverbial safeguard, and those who are alive to danger will cast about for a means of guarding against it. And there are many ways of neutralising whatever there may be potentially hurtful in the use of geology for educational ends. It has been said that the right way to make a geologist is not to teach him any geology at all to begin with. To send him first into a laboratory, give him a good long spell at observations and measurements requiring the minutest accuracy, and so saturate his mind with the conception of exactness that nothing shall ever afterwards drive it out. If a plan like this be adopted, it is easy to pick out such kinds of practical work as will not only breed the mental habits aimed at, but will also stand him in good stead when he goes on to his special subject. Goniometrical measurements and quantitative analysis will serve the double purpose of inspiring him with accurate habits of thought, and helping him to deal with some of the minor problems of geology. And I cannot hold that this practice of paying close attention to minute details will necessarily unfit a man for taking wider sweeps and more comprehensive views later on. That habit comes naturally to every man who has the making of a geologist in him directly he gets into the field. Put such a man where a broad and varied landscape lies before him, teach him how each physical feature is the counterpart of geological structure, and breadth of view springs up a native growth. I do not mean to say that the plan just suggested is the only way of guarding against the risk I have been dwelling upon. There are many others. This will serve as a sample to show what I think ought to be aimed at in designing the geological go-cart. And any such mind-moulding leads, be assured, not to hesitancy and doubt, but to conclusions, reached slowly it may be, but so securely based that they will seldom need reconstruction.

There is another aspect of the question. The uncertainties with which the road of the geologist are so thickly strewn have an immense educational value, if only we are on our guard against taking them for anything better than they really are. Of those stirring questions which are facing us day by day and hour by hour, none perhaps is of greater moment than the discussion of the value of the evidence on which we base the beliefs that rule our daily life. A man who is ever dealing with geological evidence and geological conclusions, and has learned to estimate these at their real value, will carry with him, when he comes to handle the complex problems of morals, politics, and religion, the wariness with which his geological experience had imbued him.

Now I trust the prospect is brightening. Means have been indicated of guarding against the danger which may attend the use of geology as an educational instrument. Need I say much to an audience of geologists about the immense advantages which our science may claim in this respect? In its power of cultivating keenness of eye it is unrivalled, for it demands both microscopic accuracy and comprehensive vision. Its calls upon the chastened imagination are no less urgent, for imagination alone is competent to devise a scheme which shall link together the mass of isolated observations which field work supplies; and if, as often happens, the fertile brain devises several possible schemes, it is only where the imaginative faculty has been kept in check by logic that the one scheme that best fits each case will be selected for final adoption. But, above all, geology has its home, not in the laboratory or study, but *sub Jove*, beneath the open sky; and its pursuit is inseparably bound up with a love of Nature, and the healthy tone which that love brings alike to body and mind.

And what does the great prophet of Nature tell us about this love?

> The boy beholds the light and whence it flows;
> The man perceives it die away,
> And fade into the light of common day.

Will it not then be kind to encourage the boy to follow a pursuit which will keep alive in him a joy which years are too apt to deaden; and will not the teaching of geology in schools conduce to this end? Geology certainly should be taught in schools, and for more prosaic reasons, of which the two following are perhaps the most important. Geography is essentially a school subject, and the basis of all geographical teaching is physical geography. This cannot be understood without constant reference to certain branches of geology. Again how many are the points of contact between the history of nations, the distribution and migrations of peoples, and the geological structures of the lands they have dwelt in or marched over.

But geology is not an easy subject to teach in schools. The geology of the ordinary text-book does not commend itself to the boy-mind. The most neatly-drawn sections, nay, even the most graphic representations of gigantic and uncouth extinct animals, come home to the boy but little, because they are pictures and not things. He wants something that he can handle and pull about; he does not refuse to use his head, but he likes to have also something that will employ his hands at the same time.

The kind of geology that boys would take to is outdoor work; and, of course, where it can be had, nothing better could be given them. A difficulty is that field work takes time and filches away a good deal of the intervals that are devoted to games. Still cross-country rambles and scrambling about quarries and cliffs are not so very different from a paper-chase; and if the teacher will only infuse into the work enough of the fun and heartiness which come so naturally in the open air, he need not despair of luring even the most high-spirited boy, every now and then, away from cricket and football.

But there are localities not a few—the Fen country, for instance—where it is scarcely possible to find within manageable distance of the school the kind of field-geology which is within the grasp of a beginner. But even here the teaching need not be wholly from books. The best that can be done in such cases is to make object-lessons indoors its basis. For instance, give a lad a lump of coarsish sandstone; let him pound it and separate by elutriation the sand grains from the clay; boil both in acid, and dissolve off the rusty coating that colours them; ascertain by the microscope that the sand grains are chips and not rounded pellets, and so on. All such points he will delight to worry out for himself; and, when he has done that, an explanation of the way in which the rock was formed will really come home to him. Or it is easy to rig up contrivances innumerable for illustrating the work of denudation. A heap of mixed sand and powdered clay does for the rock denuded; a watering-can supplies rain; a trough, deeper at one end than the other, stands for the basin that receives sediment. By such rough apparatus many of the results of denudation and deposition may be closely imitated, and the process is near enough to the making of mud-pies to command the admiration of every boy. It is by means like these that even indoor teaching of geology may be made lifelike.

I need not dwell upon the great facts of physical geology which have so important a bearing on geography and history; but I would, in passing, just note that these too often admit of experimental illustration, such for instance as the well-known method of imitating the rock folding caused by earth-movements. I would add that wherever in speaking of school teaching, I have used the word "boy," that word must of course be taken to include "girl" as well.

In conclusion I should like to give you an outline of the kind of course I endeavour to adopt in more advanced teaching in the case of students who are working at other subjects as well and can give only a part of their time to geology. During the first year the lectures and bookwork should deal with physical geology. In the laboratory the student should first make the acquaintance of the commoner rock-forming minerals, the means of recognizing them by physical characters, blowpipe tests, and the simpler methods of qualitative analysis, and may then go on to work at the commoner kinds of rocks and the elements of microscopic petrography. During the summer months I would take him into the field, but not do more than impress upon him some of the broader aspects of outdoor work, such as the connection between physical feature and geological structure.

During a second year stratigraphical geology should be lectured upon and studied from books, and so much of animal morphology as may be necessary for palæontological purposes should be mastered. The practical work would lie mainly among fossils, with a turn every now and again at mineralogy and petrology to keep these subjects going. Out of doors I would not yet let the student attempt geological mapping, but would put into his hands a geological map and descriptions of the geology of his neighbourhood, and he would be called upon to examine in minute detail all accessible sections, collect and determine fossils, and generally see how far he can verify by his own work the observations of those who have gone before him.

Indoor work during the third year would be devoted to strengthening and widening the knowledge already gained. Out of doors the student should attempt the mapping of a district by himself. It will be well, if there is any choice in the matter, to select one in which the physical features are strongly marked.

This sketchy outline must serve to indicate the notions that have grown up in my mind on the subject now before us, and the methods I have been led to adopt in the teaching of geology. I trust that they may be suggestive, and may call forth that kindly and genial criticism with which the brotherhood of the hammer are wont to welcome attempts, however feeble, to strengthen the corner-stones and widen the domain of the science we love so well, and to enlarge the number of its votaries.

CORRESPONDENCE.

PRIORITY OF NOMENCLATURE.

Sir,—May I ask your opinion on a question of nomenclature? About 15 years ago I discovered in Shropshire the formation which Phillips had previously found in the Malvern Hills, and had called the Hollybush Sandstone. Quite recently, Prof. Lapworth, writing in this Magazine, referred to this rock as the "Comley Sandstone," taking the name from the locality where my typical section is seen, and Prof. Blake has adopted the new nomenclature. Is this change of name in accordance with usage? We call the "Wenlock Limestone" by that name, whether it occurs in Shropshire or the Malvern Hills, and why should we not call the "Hollybush Sandstone" by Phillips' name, whether it is found in the Malvern Hills or in Shropshire? Ch. Callaway.

Wellington, Shropshire, *August 22nd*, 1890.

THE ELEVATION OF THE WEALD.

Sir,—In the rapid increase of geological literature, some of our early papers may easily be overlooked, and facts unwittingly repeated as novel which had already been noticed; but it may not often happen that the first observer is made the disciple of the second. I have no objection to legitimate criticism; but there is an objection to this obliteration of landmarks, otherwise I should not now care to address you. In Dr. Irving's note "On the Elevation of the Weald," in this month's number of your Magazine, he draws attention to the fact that in 1883 he pointed out that there was evidence of the encroachment of the sea upon the Upper Chalk in Eocene times, and that *this conclusion is accepted by Professor Prestwich.* This might lead the reader to suppose that I had overlooked this point, and that my notice of it in my paper "On the Westleton Beds" (1889), to which he refers, was in consequence of his 1883 paper. Had that been the case, I should not have failed to acknowledge, and that most willingly, my authority for so leading a fact. If, however, Dr. Irving will kindly refer to my paper "On the Thanet Sands" in Q.J.G.S. for 1852, pp. 256–260,[1] or to "The Ground Beneath Us," pp. 70–79, 1847, he will find the question discussed at some length, and *facts* and *sections* given to show that the dome of the Weald was raised after Cretaceous times, and that the Chalk

[1] Mr. Irving will find this reference in the paper which is the cause of his remarks.

was largely planed down by the early Tertiary seas, its flints contributing to the pebbles of the Woolwich and Reading beds.

Having pen in hand, I am induced to notice another slight matter in Mr. Irving's paper. He speaks of the Lenham sands as though they were first shown to be of Diestian age in 1888. He will find that that was the conclusion I arrived at in 1857 (Q.J.G.S. p. 328) and repeated in 1872 (Q.J.G.S. pp. 134, 478) and 1886 ("Geology," Vol. I. pp. 141, 303). The article in "Nature," 1888, to which he refers, is a friendly corroboration of the conclusion I had expressed. Nor were the sands on the Downs some miles further westward assumed to be contemporaneous "on the ground of approximate equality of altitude above the sea," but in that of position and structure.

Mr. Irving's observations about the Raised Beaches of Sussex described by me in 1858, and others in the Westleton shingle, might also call for some remarks; but these would lead me too far. I am also unable to follow Dr. Irving in the larger and more theoretical questions on which he enters, and respecting which we shall be better able to judge when he gives us, which I hope he will in some future paper, in *detail the local evidence* upon which his views are based.

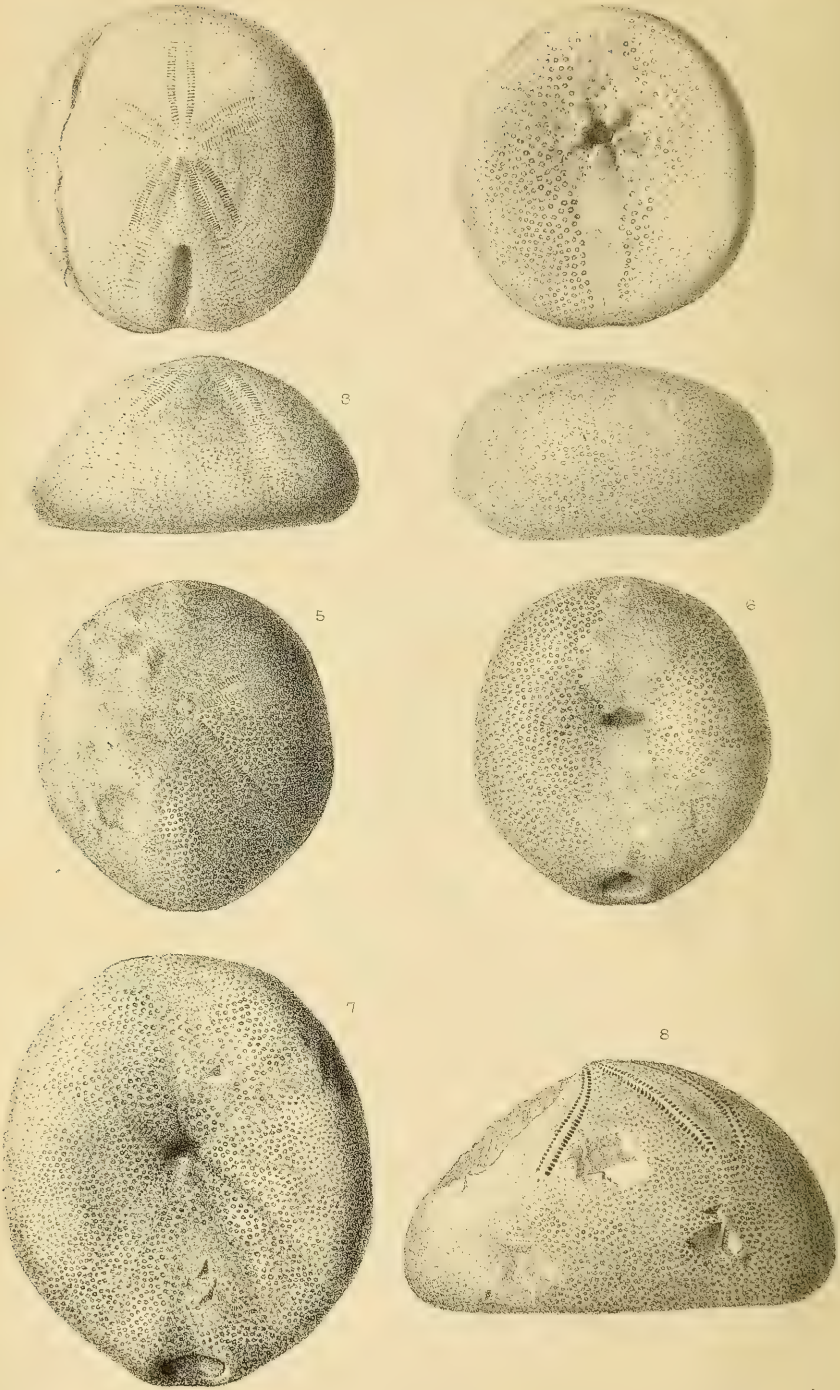
JOSEPH PRESTWICH.

SHOREHAM, KENT, *Sept.* 10, 1890.

STANDARDS OF MEASUREMENT.

SIR,—Will you kindly permit me to direct the attention of the readers of the GEOLOGICAL MAGAZINE to an objectionable feature in the writings of many of our modern geologists, namely, the use, or rather misuse, of the French metrical standard of measurements instead of the English imperial standard. There are numbers of earnest students of geology who, like myself, read eagerly and carefully, as they are issued, the Quarterly Journal, Proceedings of the Geologists' Association, and the GEOLOGICAL MAGAZINE, but being unacquainted with the French language or their standard of weights and measures, they are unable to grasp the full import of many of the learned and highly instructive papers and articles which adorn the pages of the above-mentioned journals. These students are perfectly familiar with the English standard, and any measurement from 1/16th of an inch to a fathom, or even to a mile, furnishes at once, without any mental effort, a perfectly accurate impression of size or distance, while those given according to the French standard only convey impressions of the most indefinite kind. Moreover, when we take into consideration the fact that the papers and articles referred to are written by Englishmen, published in English journals, and many of them are read before English societies, it is greatly to be deplored, not only that their usefulness is marred, but also that an important part of their contents is rendered practically unintelligible to a very large number of readers by the introduction of foreign measures and quantities. The metrical system of measures may be superior to the English imperial standard in some respects, but it is not likely that the former will ever take the place of the latter, either in England or her numerous and populous colonies, while the use of a dual system must of necessity be a fruitful source of confusion and annoyance. I must state, however, that some of the writers who use the metrical system, take the trouble to add to the measurements given in that standard, their approximate equivalents according to the imperial standard, and if all would adopt that course, or still better, reverse the order, there would be no further cause for complaint.

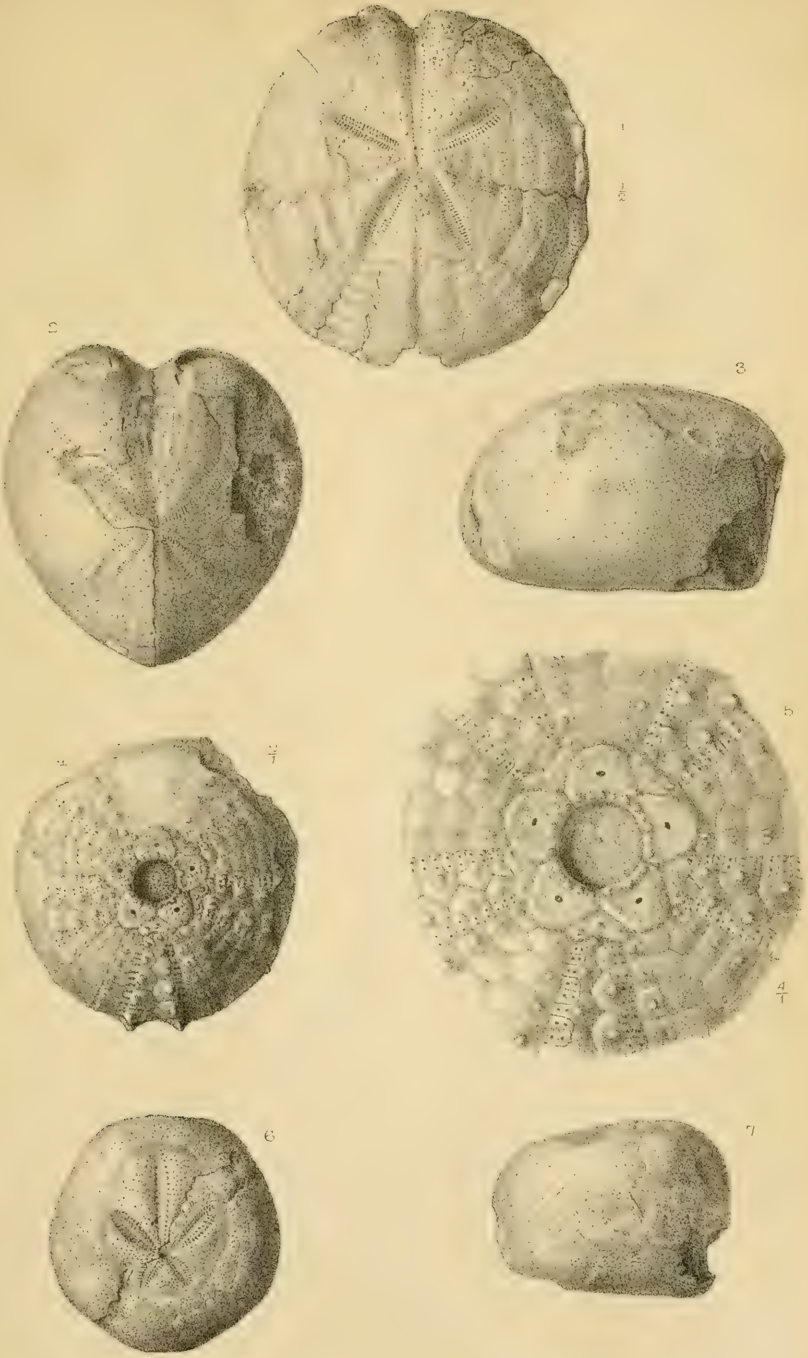
KESWICK, *Sept.*, 1890. JOHN POSTLETHWAITE.



G. M. Woodward del. et lith.

West, Newman imp.

South Australian Echinoidea.



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

South Australian Echinoidea.

THE

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NEW SERIES. DECADE III. VOL. VII.

No. XI.—NOVEMBER, 1890.

ORIGINAL ARTICLES.

I.—Some Additions to the Australian Tertiary Echinoidea.

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

(PLATES XIII. and XIV.)

THE Tertiary Echinoid fauna from the South-east of Australia is well known from the work of Duncan,[1] Laube,[2] R. Etheridge, jun.,[3] and M'Coy.[4] A collection made by H. P. Woodward, Esq., F.G.S., from the Tertiary beds of Willunga near Adelaide, enables several additions to be made. These are of interest as they considerably strengthen the Cretaceous facies which the fauna owes to the presence of such genera as *Holaster* and *Micraster*, and as they throw some additional light upon a genus the stability of which has long been questioned. The collection has been presented to the British Museum (Nat. Hist.) by H. Y. L. Brown, Esq., F.G.S., the Government Geologist for South Australia.

Dr. J. E. Taylor, during a visit to the cliffs of the Murray River at Morgan, South Australia, made a collection of fossils which is now in the Ipswich Museum. This includes two new species of Echinoids, and a description of these may be conveniently included in the present paper. For the loan of the specimens I must express my thanks to Dr. Taylor.

I.—Mr. H. P. Woodward's Collection, from Willunga.

Fam. Cidaridæ.

Gen. *Cidaris*, Leske, 1778.

Cidaris (*Leiocidaris*) sp. Duncan, Q.J.G.S. xliii. p. 412 (B.M. E 197), 1887.

There is a fragment (B.M. E 3377) of a *Cidaris* which, as it contains ambulacral and interambulacral plates, admits of identifica-

[1] P. M. Duncan, "A Description of some Fossil Corals and Echinoderms from the South Australian Tertiaries," Ann. Mag. Nat. Hist. (3) vol. xiv. pp. 161–8, pls. v. and vi. "On the Echinodermata of the Australian Cainozoic (Tertiary) Deposits," Q.J.G.S. xxxiii. 1877, pp. 42–73, pl. iii. and iv. "A Revision of the Echinoidea from the Australian Tertiaries," Q.J.G.S. xliii. 1887, pp. 411–430.

[2] G. C. Laube, "Ueber einige fossile Echiniden von den Murray Cliffs in Süd-Australien," Sitz. k. Ak. Wiss. Wien. lix. Abth. i. 1869, pp. 183-98.

[3] R. Etheridge, jun., "Description of a New Species of the Genus *Hemipatagus*, Desor, from Tertiary Rocks of Victoria, Australia; with Notes on some previously described Species from S. Australia," Q.J.G.S. 1875, pp. 444–50, pl. xxi.

[4] F. M'Coy, Prod. Pal. Victoria, dec. vi. 1879, vii. 1882.

tion. Its characters agree with those of the specimen from Bairnsdale described but not named by Dr. Duncan. This species differs from *L. australiæ* mainly by the very deeply impressed areolæ which occur in the latter.

Spines.

The collection includes a considerable number of spines which closely resemble those of *Goniocidaris*, *Phyllacanthus* and possibly also of *Heterocentrotus*. The only plates to which the spines of the *Glyphostomata* might be referred are too inperfect for description (B.M. E 3378–9).

Fam. Cassidulidæ.

Gen. *Cassidulus*, Lam. 1801.

Cassidulus longianus, sp. nov. Pl. XIII. Figs. 1–3.

Outline from above elliptical, somewhat pointed anteriorly. Abactinally it is evenly rounded; the vertex slightly precentral. Actinal surface slightly concave with the mouth in the centre of the depression. A wide median bare band runs backward from the mouth.

Apical system at vertex. Five radial and four basal pores. Madreporite large, occupying whole of centre of the system.

Ambulacra. — Petals sublanceolate; flush; open below; pores yoked. The single pores of the extrapetaloid plates are on the adoral margin. Petals nearly equal: the posterior laterals are slightly narrower and less lanceolate than the anterolateral.

Peristome anterior: at deepest part of the slight actinal depression. Floscelle very prominent. Phyllodes very narrow at oral end, but expanding into wide areas with five pores in the outer row of each side. Bourrelets very prominent. Mouth pentagonal.

Anus long, narrow and oval; situated at upper end of a long narrow groove, which however barely influences the posterior margin.

Dimensions.	Largest specimen.	Type, Fig. 1.	Type, Fig. 2.
Length	65 mm.	45 mm.	43 mm.
Width	56 ,,	42 ,,	40 ,,
Height	30 ,,	22 ,,	20 ,,
Distance of apex from anterior edge ...	27 ,,	19 ,,	...
Distance of mouth ,, ...	26 ,,	...	17 ,,
Maximum width of poriferous zone: antero-lateral ambulacrum ...	2·5 ,,	1·5 ,,	
Maximum width of poriferous zone: postero-lateral ambulacrum ...	2·0 ,,	1·2 ,,	
Length of antero-lateral ambulacrum ...	20 ,,	11 ,,	
Length of postero- ,, ,, ...	22 ,,	12 ,,	

Cassidulus has not previously been described from the Australian Tertiaries. The genus is mainly Cretaceous, but a few species occur in the Eocene. *Cassidulus longianus* is a well-marked species: the bare median band, one of the features of the subgenus *Pygorhynchus*, the long anus and short petals form a series of characters to be met with in no other species of the genus. It most resembles some of the United States Cretaceous forms such as *C. subquadratus*, Conrad.[1]

[1] T. A. Conrad, Journ. Ac. Nat. Sci. Phil. [2] iv. p. 291, pl. xlvii. fig. 19.

Gen. *Echinolampas*, Gray, 1825.

Echinolampas ovulum, Laube.

Sitz. k. Ak. Wiss. Wien. lix. Abth. i. 1869, pp. 191–2.

Laube in 1869 briefly described a specimen from the Murray Cliffs, which he temporarily named *E. ovulum* as it was too imperfect for formal diagnosis. Prof. Duncan subsequently referred a specimen from Bairnsdale (B.M. E 1107) to this species. Laube's type is in the Palæontological Collection of the Hof Museum in Vienna, and owing to the kindness of the Director, Dr. Fuchs, I recently had the opportunity of examining it; there can be no doubt of the correctness of Prof. Duncan's identification. As the species has hitherto been neither figured nor described, this opportunity may as well be taken for doing so: in the following diagnosis both specimens have been used.

Echinolampas ovulum, Laube. Pl. XIII. Figs. 7–8.

Laube, Sitz. k. Ak. Wiss. Wien. Bd. lix. Abth. i. 1869, pp. 191-2.
Duncan, Q.J.G.S. 1877, xxxiii. p. 66; 1887, xliii. p. 420.

Outline seen from below an elongated pentagon with rounded angles; sides tumid, rounding off into the concave actinal surface: tapering posteriorly to a slight rostrum, at the end of which is the anus: well rounded in front.

In elevation it is high, with the vertex behind the apical disc.

Vertex blunt, at the posterior third of the test.

Apical system anterior: details unknown.

Ambulacra with lanceolate petals, open below. The posterior pair the larger. Pores yoked. The petals extend more than two-thirds to the ambitus. In the posterior ambulacra the pore areas are equal (as in *Palæolampas*); in the anterior unequal (as in *Echinolampas*).

Peristome: mouth rounded pentagonal: broader than long: slightly anterior: at deepest part of the actual concavity.

Floscelle rudimentary, formed by slight bourrelets.

Anus elliptical, transverse: situated at the end of a slight rostrum.

Tuberculation: of close-set, uniform granules with impressed areolæ.

Dimensions.	Laube's type.	B.M. E1107.
Length	64 mm.	57 mm.
Width: at posterior third	56 ,,	48 ,,
,, anterior third	52 ,,	43 ,,
Height	36·5 ,,	33·5 ,,
Apical disc: distance from anterior end ...	25 ,,	23 ,,

Echinolampas posterocrassus, sp. nov. Pl. XIII. Figs. 4–6.

Form a depressed rounded pentagon: sides tumid. Apex a little behind the calycinal system; anterior slope gentle.

Apical system precentral; basal pores large: those of the posterior pair the further apart.

Ambulacra long, narrow: slightly petaloid but almost parallel:

open below. The pore pairs of the anterior pair slightly unequal. Those of the posterior pair markedly so.

Mouth anterior: in the highest part of the actinal depression: pentagonal: phyllodes very rudimentary.

Anus triangular: infra-marginal.

DIMENSIONS.

Length	43	mm.
Width: at $\frac{1}{3}$ of length from anterior end	36	,,
,, ,, posterior end	36·5	,,
Height	21	,,
Distance of apical disc from anterior end	17	,,
Length of petaloid portion of anterior ambulacrum	10	,,
Max. width of ,, ,, ,, ,, ...	3	,,
Length of petaloid portion of posterior ambulacrum { anterior poriferous area	17	,,
{ posterior area	12	,,
Max. width of ,, ,, ,, ambulacrum	3·5	,,

This species belongs to the group of Echinolampads of which *E. similis*, Ag., may be taken as the type. It differs from this by its greater proportional breadth, and the greater inequality of the poriferous zones in each of the posterior petals. It can be easily distinguished from other Australian species of this genus by its depressed form and the marked inequality in the length of the poriferous zones of the petaloid portions of the posterior ambulacra. Its general form reminds one of *Echinolampas dispar*, Fritsch,[1] from the Eocene of Borneo; from this it differs in that the mouth is more excentric in position, the anus is triangular (instead of round as in the Malaysian species), and in the latter the posterior part of the test is much wider than the anterior.

Fam. ANANCHYTIDÆ.

Genus *Cardiaster*, Forbes, 1852.

Cardiaster tertiarius, sp. nov. Pl. XIV. Figs. 2 & 3. B.M. E 3382.

Outline seen from above cordate: the test tapering gently posteriorly; the anterior end is broad, well rounded, and marked by the deep anterior groove. In elevation it is seen to be sloping steeply in front and very high behind; the posterior interradius is elevated into a slight keel. Vertex at a quarter of the length of the test from the anterior end. Posterior margin truncate and vertical, with the anus high upon this area. In this position the actinal surface appears straight.

Apical system central; elongate; only the right half is known.

Ambulacra flush: the pores of the posterior poriferous zones of each of the paired ambulacra larger than the anterior. Pores of unpaired anterior ambulacrum minute.

Tubercles crenulate and perforate.

DIMENSIONS.

Length	42	mm.
Width at $\frac{1}{3}$ length from anterior end of test... ...	21	,,
,, ,, posterior ,, ...	18	,,
Height	25	,,

[1] K. von Fritsch, "Die Echiniden der Nummuliten-Bildungen vou Borneo," Palæontographica, Supp. III. 1. 1, Hft. 2, 1877, p. 89, pl. xiii. figs. 2 and 3.

Cardiaster has not hitherto been described except from the Cretaceous. The late Rev. J. E. Tenison-Woods recorded[1] the genus from Mt. Gambier, but gave neither figure nor description; and, as has been often pointed out, little value can be attached to his generic determination of Echinoidea. The present specimen is somewhat broken, and, as is so often the case in this genus, the fasciole cannot be seen; nevertheless the general form, the deep anterior groove, and the tuberculation, leave no doubt of its correct generic position.

The species agrees most closely with the European *C. ananchytis*, and most nearly with the variety *cordiformis*.[2] It differs, however, in the greater prominence of the ridges that bound the anterior groove; the test is higher, the anterior end is steeper, and instead of the gentle slope of the posterior interradium, this forms a horizontal keel, which is terminated abruptly by the almost vertical posterior margin.

Fam. SPATANGIDÆ.

Division *Prymnadete.*

Genus *Pericosmus*, Ag., 1847.

Sp. 1. *Pericosmus M'Coyi*, sp. nov.

Pericosmus compressus, M'Coy. Prod. Pal. Victoria, dec. vii. 1882, pp. 21–2, pl. lxvii. fig. 2, and lxviii. (Non *Megalaster compressus*, Dunc.)

Sp. 2. *Pericosmus compressus*, Dunc. sp. Pl. XIV. Fig. 1.

Megalaster compressus, Dunc. Q.J.G.S. 1877, vol. xxxiii. p. 62, fig. 1.

Prof. Duncan, in 1877, described as *Megalaster compressus* a large Spatangoid, evidently an ally of *Pericosmus*, but for which, owing to the absence of fascioles, he instituted a new genus. Prof. M'Coy five years later, in the course of his admirable figures and descriptions of the Victorian *Pericosmi*, named one species *P. compressus*, because he was deeply impressed with its resemblance to the specimen described by Dr. Duncan, and with the probability that *Megalaster* would turn out to be only a badly-preserved representative of this genus. Prof. von Zittel[3] seems previously to have entertained the same doubts, as he only accepted *Megalaster* with a query. Prof. Duncan, in his "Revision of the Australian Echinoidea," in 1887, referred to Prof. M'Coy's remarks, and after a brief discussion left the question open. In his recent "Revision of the Echinoidea,"[4] however, the genus is again quoted without any expression of doubt.

The question of the retention of the genus *Megalaster* depends upon whether the absence of fascioles in the type-specimen is due to their never having been developed or to their having been obliterated during weathering. The specimen has certainly been greatly worn; none of the tubercles on the abactinal surface are shown in Prof. Duncan's drawing, nor are they preserved in the British Museum specimen. It is therefore not surprising that

[1] J. E. Tenison-Woods, Geol. Obs. in South Australia, 1862, p. 77.
[2] Samuel Woodward, Geology of Norfolk, 1833, p. 50, pl. v. fig. 6.
[3] von Zittel, Handbuch der Palaeontologie, i. 1889, p. 541.
[4] Journ. Linn. Soc. Zool. xxiii. 1889, pp. 221-2.

fascioles cannot now be recognized; but in his discussion of the question Prof. Duncan emphasizes the fact that the specimen is certainly specifically distinct—quite apart from the fascioles—from any described species of *Pericosmus.* Prof. M'Coy, on the other hand, regarded it as probably identical with his *P. compressus,* though he noted that in addition to the fascioles the latter has a convexity, instead of a concavity, near the summit of the unpaired interradius.

In Mr. H. P. Woodward's collection there is a *Pericosmus* which agrees in the character noted by Prof. M'Coy, and in other points with Dr. Duncan's specimen. After a comparison of this with the specimen of *Megalaster*, I entertain no doubt that the two are specifically identical, and that consequently *Megalaster* must be abandoned.

As to the second question, whether *Pericosmus compressus*, Dunc. sp., is the same as *P. compressus*, M'Coy, I agree with Dr. Duncan rather than with Prof. M'Coy and Prof. Hutton. The two species differ in the following points: *P. compressus*, Dunc. sp., is longer than wide, whereas the other is wider than long: in the former the anteal sulcus is wider and shallower; the anus is oval instead of round; the anterior slope is steeper; the test is higher; the apical disc is more anterior; there is a concavity behind the apical disc; the ambulacra are less lanceolate, blunter and sinuous. These form a combination of characters that are quite sufficient to continue the separation of the species. But the absorption of *Megalaster* in *Pericosmus* necessitates the adoption of a new name for the later species. I have much pleasure in calling it after Prof. M'Coy, as, owing to his admirable work, his name must always be associated with the species; its renaming is only required owing to the perspicuity with which Prof. M'Coy interpreted Prof. Duncan's description and outline figure, and to the caution with which he hoped to save palæontological nomenclature from a useless synonym.

After Prof. Hutton's[1] remark, it is perhaps advisable to compare *P. M'Coyi* with the description of *Meoma crawfordi*, Hutton. The Australian species differs from the New Zealand one in that (1) it is not a *Meoma*; (2) it is broader than long—not longer than broad, as shown by Prof. Hutton's measurements; (3) the antero-lateral ambulacra are equal or slightly longer than the postero-lateral.

II.—Dr. Taylor's Collection. From the banks of the Murray River at Morgan.[2]

Fam. Arbaciidæ.

Gen. *Cœlopleurus*, Ag., 1840.

Cœlopleurus paucituberculatus, sp. nov. Pl. XIV. Figs. 4 and 5.

Test tumid; depressed abactinally; concave below. Circular.

[1] F. W. Hutton, "On the Correlations of the 'Curiosity-Shop Bed,' in Canterbury, New Zealand," Q.J.G.S. 1885, vol. xli. p. 554.

[2] The sections at this point have been fully described by Prof. Tate in his "Notes on the Physical and Geological Features of the Lower Murray River," Trans. Roy. Soc. S. Australia, 1885, vol. vii. p. 35.

Apical system large; ornamented with tubercles; radials narrow. Anus slightly elliptical.

Ambulacra: narrow above with small tubercles; but wide at the ambitus with large tubercles; both sets are uncrenulate and imperforate. The bosses are large and fill up nearly the whole of the areola. Two rows of small flat granules run up the centre of each area at the ambitus, but disappear above. Eleven plates in a vertical series.

Interambulacra.—The bare median band at the summit of each area is bounded on either side by a row of large, and a row of small granules. At the ambitus the number of granules widen, and there are three rows of subequal granules on either side. No primary tubercles. Fifteen plates in the vertical series.

Mouth large; in a concavity. Buccal slits broad.

Dimensions.

Diameter	19 mm.
Height	12 ,,
Width of ambulacral area at ambitus	7 ,,
Width of interambulacral	6 ,,
Diameter of anus	3 ,,

Distribution: Middle Murravian, Morgan, S. Australia (preserved in the Ipswich Museum).

Cœlopleurus is a typically Cainozoic genus, but has not previously been recorded from the Australian Tertiaries. The type-specimen of the new species is broken, but the apical disc and most of the abactinal surface, a complete ambulacrum and the halves of the two adjoining interambulacra are shown: all the points in the anatomy of the test can therefore be determined. *Cœlopleurus paucituberculatus* is very easily distinguished from any other species of the genus by the complete absence of primary tubercules on the interradii (the character which has suggested its name), and by the persistence to the apical disc of a pair of granules on either side of the bare median area. In the latter feature it resembles *Cœlopleurus sindensis*, Dunc. and Sl., which is apparently its nearest ally. It can be easily distinguished from this by the absence in the new species of the primary ambital interradial tubercles.

Fam. Clypeastridæ.

Gen. *Clypeaster*, Lam., 1816.

Clypeaster gippslandicus, M'Coy.

Prod. Pal. Victoria, Dec. vi. 1879, pp. 33–5, pl. lix.

There is one well-marked specimen in the collection which is of interest, as the species is usually characteristic of the uppermost beds of the South Australian and Victorian Cainozoic series.

Subgen. *Monostychia*, Laube.

Monostychia australis, Laube, sp.

Sitz. k. Akad. Wiss. Wien. lix. Abth. i. 1869, p. 190, fig. 3.

The collection includes several specimens of this species, and one belonging to the var. *elongata*.

Fam. Spatangidæ.

Gen. *Hemiaster*, Desor, 1857.

Hemiaster planedeclivis, sp. nov. Pl. XIV. Figs. 6 and 7.

Pentagonal; thick with tumid sides: the abactinal surface is depressed and flat, and slopes gently forward from the vertex: the posterior side is steep, almost vertical.

Apical area excentric posteriorly: in front of the vertex. Construction not fully known: it is ethmolysian, and there are two large pores in the antero-lateral basals. The postero-lateral basals apparently also bear a pore each.

Ambulacra: the anterior is long and narrow with small pores: it is lodged in a slight depression. The petaloid portions of the lateral pairs are in broader and shorter depressions. The anterior pair are slightly sinuous and nearly twice as long as the posterior.

Fasciole: peripetalous: it is irregularly hexagonal: the anterior side broadens considerably in the middle. The fasciole is always wider where it traverses an ambulacrum.

Anus: high on the posterior margin.

Mouth: at a moderate distance from the anterior margin: the labrum is strongly projecting.

Dimensions.

Length	31 mm.
Width: at one-third length from anterior end ...	25 ,,
,, ,, ,, posterior end ...	28 ,,
Height	23 ,,
Length of anterior petal	9 ,,
Width of ,, ,, ...	3 ,,
Length of posterior petal	5 ,,
Width of ,, ,, ...	2 ,,
Apical disc: distance from anterior end	18 ,,

Distribution. — Middle Murravian, Morgan, South Australia (preserved in the Ipswich Museum).

Remarks.—*Hemiaster planedeclivis* is a species of a very Cretaceous aspect, and its closest affinity is with the group of which *H. fourneli*, Desh.,[1] *H. nucleus*, Des.,[2] and *H. palpebratus*, Lor.,[3] are typical representatives: it has the high posterior vertex, the tumid sides, the flat abactinal surface, the almost vertical posterior margin, the small posterior petals, and well-developed labrum which is characteristic of this group. Nevertheless it differs clearly from any described species; thus from *H. palpebratus* it can be readily distinguished by the greater flatness of its abactinal surface, and the absence of the tumid antero-lateral interradii seen in that species. The widely-distributed *H. fourneli* is probably its nearest ally, and from this it may readily be separated by its greater breadth and the flatness of the upper side. From the whole of this group of *Hemiasters*, in fact, the flatness of the abactinal slope, the proportions of the pairs of petals, and the irregularity of the fasciole form a combination of characters that enable this species to be easily distinguished.

[1] Agassiz and Desor, Catalogue raisonné, pt. 3, Ann. Sci. nat. (3) viii. 1847, p. 16.
[2] Agassiz and Desor, *op. cit.* p. 17.
[3] De Loriol, Faune crétacique du Portugal, Echinodermes, II. fasc. 2, Lisbon, 1888, pp. 103-4, pl. xx. figs. 1-3.

The genus *Hemiaster* has not been hitherto described from Australia, but a species is known from New Zealand. *H. planedeclivis* belongs, however, to a very different group to this *H. posita*, Hutton,[1] which has a cordate, inflated test, with the pores on the inner side of the postero-lateral ambulacra obliterated near the apical area. Moreover, the latter species is said in the diagnosis to have neither subanal nor peripetalous fasciole. If this be correct, the species is not a *Hemiaster*, but must be transferred to the genus *Epiaster*.

The generic determination of this Echinoid may be considered doubtful by the French palæontologists who separate from *Hemiaster* all the Cainozoic forms. But apart from the disputed question of the validity of the new genera to which these species are referred, the affinities of *H. planedeclivis* are so distinctly with the Cretaceous group that it must be regarded as a true typical *Hemiaster*.

III.—From Nullarbor Plains.

During the exploration of the country between Port Augusta and Eucla,[2] a few Echinoidea were collected from the Nullarbor limestone; these have also been presented to the British Museum (Nat. Hist.) by H. Y. L. Brown, Esq. At Tallowan Well in the Fowler's Bay district an *Echinolampas*, sp., and some fragments probably referable to *Eupatagus* were collected. The other specimens were without definite locality: they are *Echinus woodsi*, Laube, and *Lovenia forbesi* (Woods and Dunc.).

IV.—The Affinities of the Echinoid Fauna.

Many attempts have been made to classify the Australian Cainozoic deposits, and to establish definite correlations of the beds of the various localities with each other, and with the European formations; no very definite classification has, however, as yet been agreed upon. But an examination of the faunal lists clearly shows that various horizons are represented, and until the relations of these are at least approximately known, no definite conclusions as to the affinities of the fauna can be established.

As Mr. Woodward's collection was made at a new locality, it is necessary to consider the relations of the fauna to those from other places in South Australia and Victoria. Of the five recognizable species three are new, but the other two are well-marked forms; they suggest that the beds belong to the lowest of the three divisions into which it seems generally agreed that these Australian Cainozoic deposits can be divided. As to the terms to be applied to these divisions, however, opinions differ greatly. The banks of the Murray River exhibit the longest continuous sections, and afford the best oppor-

[1] F. W. Hutton, Cat. Tert. Mollusca and Echinodermata of New Zealand, New Zealand Geol. Surv., Miscell. Publications, No. IX. 1873, p. 42. Hector, Cat. of Geol. Exhibits, New Zealand Court, India and Colonies Exhibition, London, 1886, p. 54, fig. 1.

[2] H. Y. L. Brown, "Report of Country passed over from Port Augusta to Eucla," Adelaide, 1885.

tunity for the working out of the sequence of palæontological zones; it is therefore probable that this series will serve as the scale with which the disconnected beds of other localities will be compared; hence Prof. Tate's terms,[1] Upper, Middle and Lower Murravian, may be conveniently adopted. The beds at Mordillac, and some other Gippsland localities belong to the highest part of the marine Cainozoics, and their correlation with the Upper Murravian seems generally admitted. The beds at Mount Gambier, Wauru Ponds, Muddy Creek, Geelong, Bird Rock Point, and Cape Otway are referred to the Middle Murravian; no serious effort to establish a precise correlation of the beds at these localities seems to have been made, but their Echinoid faunas have much in common; thus of the four species from Mount Gambier, three occur in the middle division of the Murray River beds, and the fourth occurs at Cape Otway; of the four at Cape Otway, one (*Holaster difficilis*—an unsatisfactory species) is peculiar, one occurs at Mount Gambier, and the other two in the Middle Murravian of the typical locality.

The collection made by Mr. Woodward has a somewhat oldish facies: *Pericosmus compressus* (Dunc.) is elsewhere commonest in the Lower Murravian beds, while the species characteristic of the upper division are absent. Hence though the evidence is insufficient for any positive opinion, it is probable that the beds at this point will turn out to be Lower Murravian.

When considering the distribution of the Australian Cainozoic Echinoidea, one must compare them with those from New Zealand made known to us by the labours of Prof. von Zittel[2] and Prof. F. W. Hutton.[3] The latter has described a fauna from the Curiosity Shop beds, which in its main features greatly resembles that of South Australia and Victoria, while some of the species are regarded as identical. The brief diagnoses given by Prof. Hutton do not, in the absence of illustrations, allow of any close comparison being made between them and the Australian species: nevertheless the resemblances are sufficient to show that they are of approximately the same age, and to necessitate their inclusion in any full consideration of the relations of the fauna.

The attempt to correlate the Murravian beds with their European equivalents is of course much more difficult than their classification. Prof. Duncan, distrusting the application of European terms in such distant regions, calls the Mount Gambier beds Middle Cainozoic, those below that horizon the Lower, and those above the Upper Cainozoic.[4] Profs. Selwyn and M'Coy and the authors of Skene's map of Victoria, agree in the main with Prof. Duncan, though they call the Gippsland beds Pliocene and the others Miocene and

[1] Tate, "Notes on the Correlations of the Coral-bearing Strata of South Australia," Trans. Roy. Soc. South Australia, vol. i. 1878, pp. 120–3.

[2] K. von Zittel, "Neue Mollusken und Echinodermen aus Neu-Seeland," Novara Reise, Palaeontologie.

[3] F. W. Hutton, "Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand," New Zealand Geol. Soc., Miscell. Public. ix. 1873.

[4] P. M. Duncan, "On the Fossil Corals of the Australian Tertiary Deposits," Q.J.G.S. xxvi. 1870, p. 315.

Oligocene: as long as we regard these terms as implying only a general homotaxis, they are synonymous with and more convenient than the others. Professor Hutton[1] however assigns his New Zealand Echinoidea to the Cretaceo-Tertiary; but the fact that more than 20 per cent. of the species from this horizon are still living would appear to conclusively negative this opinion. Prof. Hutton, however, in his latest note,[2] correlates the Cobden with the Ototara limestone, and says that the fossils "indicate an Upper Eocene or Lower Miocene, *i.e.* an Oligocene age." Prof. Tate's conclusions[3] are rather intermediate between the two extremes of Prof. M'Coy on the one hand and Prof. Hutton's earlier paper on the other: he correlates the Upper Murravian as Miocene and the Middle Murravian as Eocene. Mr. Dennant[4] again would make the beds older. As the Upper Muddy Creek beds, including Mordillac, contain only 6·5 per cent. of living species, he assigns them to the Oligocene, and the lower beds with 1·5 per cent. to the Lower Eocene. Nummulites, it may be remarked, also occur on this horizon. The Echinoidea seem to support the views of Mr. Dennant. The presence of so many genera peculiar to or characteristic of the Cretaceous, such as *Cassidulus*, *Catopygus*, *Cardiaster*, *Holaster*, and *Micraster*, and the closer alliance of some species, as *H. planedeclivis*, to the Cretaceous rather than the Tertiary representatives of their genera, suggest that the fauna is early Tertiary.

Some other genera, as *Cœlopleurus* and *Echinolampas*, are characteristically Eocene, and some peculiar forms have their nearest allies in the same period: further the absence of the typical Upper Tertiary genera is very noticeable; both of these points strengthen the same conclusion. Moreover, as far as the Echinoidea go, the differences of the faunas of the Upper and Lower Murravian are too slight to allow one to consider them as separated by so long a period as that between the Eocene and the Pliocene; there is certainly nothing in the Echinoid fauna that would debar the uppermost beds from entering the Oligocene.

But the real correlation of these beds will depend more on the Mollusca than on the Echinoidea: the latter are so anomalous a collection that little faith can be attached to their evidence on this subject. The interest of the fauna depends on its bearing on other problems. It seems to be composed of two constituents: about a third are species of the ordinary Palæarctic Upper Cretaceous genera; these seem to have migrated southwards and became mingled on their journey with a fauna that agrees most closely with that of the Eocenes of India and Malaysia. No abyssal types were picked up on the march, nor do any of the species retain any

[1] F. W. Hutton, Q.J G.S. xli. 1885, pp. 558-64.

[2] "On some Fossils lately obtained from the Cobden Limestone at Greymouth," Trans. N. Zealand Inst. xx. 1888, pp. 267-9.

[3] Tate, "Census of the Fauna of the Older Tertiary of Australia," Journ. R. Soc. N. S. Wales, xxii. 1888, pp. 242.

[4] J. Dennant, "Notes on the Muddy Creek Beds, with Brief Remarks on other Tertiary Strata of S. Western Victoria," Trans. R. Soc. S. Australia, vol. xi. 1889, pp. 53-4.

trace of the influence of a deep-sea habitat. Hence the route may have followed the coasts of Asia and Malaysia, in which case we may hope for much further light to be thrown upon its progress by collectors in that area; or the line may have lain across what is now occupied by the deep abysses of the Indian Ocean, but if so it must have occurred before its bed had subsided to anything like its present depth.

EXPLANATION OF THE PLATES.

PLATE XIII.

FIGS. 1, 2, and 3. *Cassidulus longianus*, sp. nov., Willunga, S. Australia. Nat. size. Brit. Mus. E 3380. Fig. 1. Abactinal view. Fig. 2. Actinal view of another specimen. Fig. 3. Side view of former specimen.

FIGS. 4, 5, and 6. *Echinolampas posterocrassus*, sp. nov., Willunga. Nat. size. Brit. Mus. E 3381. Nat. size. Fig. 4. Side view. Fig. 5. Abactinal view. Fig. 6. Actinal view of same specimen.

FIGS. 7 and 8. *Echinolampas ovulum*, Laube. Bairnsdale, Victoria. Brit. Mus. E 1107. Nat. size. Fig. 7. Actinal view. Fig. 8. Side view of same specimen.

PLATE XIV.

FIG. 1. *Pericosmus compressus* (Dunc.). Willunga. Brit. Mus. E 3383. Half size.

FIGS. 2 and 3. *Cardiaster tertiarius*, sp. nov. Willunga. Brit. Mus. E 3382. Nat. size. Fig. 2. Abactinal. Fig. 3. Side view of same specimen.

FIGS. 4 and 5. *Cœlopleurus paucituberculatus*, sp. nov. Morgan, S. Australia. Fig. 4 × 2 dia. Fig. 5. Diagram of apical disc and surrounding plates × 4 dia. Ipswich Museum.

FIGS. 6 and 7. *Hemiaster planedeclivis*, sp. nov. Morgan, S. Australia. Nat. size. Ipswich Museum.

II.—QUATERNARY CHANGES OF LEVELS.

By WARREN UPHAM,
of the United States Geological Survey.

THE article by Prof. J. W. Spencer in the last May number of this MAGAZINE brings together many evidences of high continental elevation of North America preceding the Pleistocene or Glacial period. Though Professor Spencer has not proceeded to interpret these observations as revealing in continental elevation the probable cause of the severely cold climate and accumulation of ice-sheets during the Glacial period, I believe that this is a legitimate conclusion, and that it strongly re-enforces the arguments long ago advanced by Lyell and Dana, and recently emphasized anew by Wallace.

But certain other observations bearing on the length of the Postglacial or Recent epoch lead me to differ from Wallace, who combines high elevation with maximum eccentricity of the earth's orbit as necessary concomitant conditions of glaciation. Closely accordant computations of the length of Postglacial time have been reached quite independently by Prof. N. H. Winchell, from the rate of recession of the Falls of Saint Anthony;[1] by Dr. E. Andrews, from

[1] Quart. Journ. Geol. Soc., vol. xxiv. 1878, pp. 886-901; Geology of Minnesota, Fifth Annual Report, for 1876; and Final Report, vol. ii. 1888, pp. 313-341, with numerous plates and maps.

the rate of erosion of the shores of Lake Michigan and the resulting accumulation of beach sand blown into dunes at the south end of the lake;[1] by Prof. G. F. Wright, from the rate of filling of small peat bogs in hollows surrounded by kames and osars at Andover, Mass., and from the erosion of streams tributary to Lake Erie;[2] by Mr. G. K. Gilbert, from the recession of Niagara Falls;[3] and by Prof. B. K. Emerson, from the rate of deposition of modified drift in the Connecticut valley at Northampton, Mass.[4] These measurements and estimates agree in showing that only 6,000 to 10,000 years have passed since the ice-sheet of the last Glacial epoch was melted away from the northern part of the United States. It is therefore impossible to refer that glaciation to an epoch of increased eccentricity which ended 80,000 years ago. An equally small estimate is also indicated by the studies of Gilbert[5] and Russell[6] for the time since the last great rise of Lakes Bonneville and Lahontan, which appear to have fluctuated contemporaneously with the growth and departure of the North American ice-sheets.

In Wales and Yorkshire the amount of denudation of limestone rocks on which boulders lie has been regarded by Mr. D. Mackintosh as proof that a period of not more than 6000 years has elapsed since the boulders were left in their present positions.[7] The vertical extent of this denudation, averaging about six inches, is nearly the same with that observed in the south-west part of the Province of Quebec by Sir William Logan and Dr. Robert Bell, where veins of quartz marked with glacial striæ stand out to various heights not exceeding one foot above the weathered surface of the enclosing limestone.[8]

Another indication that the final melting of the ice-sheet upon British America at the close of the last Glacial epoch was separated by only a very short interval, geologically speaking, from the present time, is seen in the wonderfully perfect preservation of the glacial striation and polishing on the surfaces of the more enduring rocks. Of their character in one noteworthy district, Dr. Bell writes as follows:—"On Portland promontory on the east coast of Hudson's Bay, in latitude 58°, and southward, the high rocky hills are completely glaciated and bare. The striæ are as fresh-looking as if the ice had left them only yesterday. When the sun bursts upon these

[1] Transactions of the Chicago Academy of Sciences, vol. ii. James C. Southall's "Epoch of the Mammoth and the Apparition of Man upon the Earth," 1878, chapters xxii. and xxiii.

[2] Am. Journ. Sci. III. vol. xxi. pp. 120-3, Feb. 1881; "The Ice Age in North America," 1889, chapter xx. p. 466.

[3] Nature, vol. xxxiv. p. 560; Proc. Am. Assoc. for Adv. of Science, vol. xxxv. for 1886, p. 222; "The History of the Niagara River," Sixth Ann. Rep. of Commissioners of the State Reservation at Niagara, for 1889, pp. 61–84.

[4] Am. Journ. Sci. III. vol. xxxiv. pp. 404-5, Nov. 1887.

[5] U.S. Geol. Survey, Second Annual Report, p. 188.

[6] U.S. Geol. Survey, Monograph xi. "Geological History of Lake Lahontan," p. 273.

[7] Quart. Journ. Geol. Soc. vol. xxxix. 1883, in Proceedings, pp. 67–69. Compare *id.* vol. xlii. 1886, pp. 527–539.

[8] Bulletin of the Geological Society of America, vol. i. 1889, p. 306.

hills after they have been wetted by the rain, they glitter and shine like the tinned roofs of the city of Montreal."[1]

Debarred by the shortness of the Postglacial epoch from attributing the Ice Age to the astronomic condition of maximum eccentricity, so ably advocated by Croll, we must look for other causes of this extraordinary geological period; and these seem to be found in great uplifts of the glaciated areas, of which for North America Prof. Spencer has given an impressive review. The submarine border of the continental plateau to depths of more than 3000 feet is cut by valleys or channels, which if raised above the sea-level would be fjords or cañons. These can be no other than river-courses eroded while the land stood much higher than now; and its subsidence evidently took place in a late geologic period, else the channels would have become filled with sediments.

According to the United States Coast Survey charts, as noted by Spencer, the bottom of a submerged valley just outside the delta of the Mississippi is found by soundings at the depth of 3000 feet. This valley is a few miles wide, and is bounded by a plain of the sea-bed from 900 to 1200 feet above its floor. It thus appears that the country north of the Gulf of Mexico has been raised for a short time to a height of not less than 3000 feet; and it is important to note in passing that an equal uplift would wholly close the Strait of Florida, 2064 to 3000 feet deep, through which the Gulf Stream now pours into the North Atlantic.

The continuation of the Hudson River valley has been traced by detailed hydrographic surveys to the edge of the steep continental slope at a distance of about 105 miles from Sandy Hook. Its outermost 25 miles are a submarine fjord three miles wide and from 900 to 2250 feet in vertical depth, measured from the crests of its banks, which with the adjacent flat area decline from 300 to 600 feet in depth below the present sea-level. The deepest sounding in this fjord is 2844 feet.[2]

An unfinished survey by soundings off the mouth of Delaware Bay finds a similar valley submerged nearly 1200 feet, but not yet traced to the margin of the continental plateau.

Again, the United States Coast Survey and British Admiralty charts, as Spencer states, record submerged fjord outlets from the Gulf of Maine, the Gulf of Saint Lawrence, and Hudson Bay, respectively 2664 feet, 3666 feet, and 2040 feet below sea-level. The bed of the old Laurentian River from the outer boundary of the Fishing Banks to the mouth of the Saguenay, a distance of more than 800 miles, shown by Professor Spencer's map, is reached by soundings 1878 to 1104 feet in depth. Advancing inland, the sublime Saguenay fjord along an extent of about fifty miles ranges from 300 to 840 feet in depth below the sea-level, while in some places its bordering cliffs, one to one and a half miles apart, rise abruptly 1500 feet above the water.[3]

[1] *Id.* p. 308.

[2] Rep. of U.S. Coast and Geodetic Survey, 1884, pp. 435–8, with map and profile; also in Amer. Journ. Sci. III. vol. xxix. pp. 475–480, June, 1885. Compare Bulletin Geol. Soc. Am. vol. i. 1889, pp. 563–7.

[3] J. W. Dawson, "Note on the Post-Pliocene Geology of Canada," 1872, p. 41.

Greenland is divided from the contiguous North American continent and archipelago by a great valley of erosion, which is estimated from soundings and tidal records to have a mean depth of 2510 feet below sea-level for 680 miles through Davis Strait; 2095 feet for 770 miles next northward through Baffin Bay; and 1663 feet for the next 55 miles north through Smith Strait.[1]

On the Pacific coast of the United States, Professor Le Conte has shown that the islands south of Santa Barbara and Los Angeles, now separated from the mainland and from each other by channels 20 to 30 miles wide and 600 to 1000 feet deep, were still a part of the mainland during the late Pliocene and early Quaternary periods.[2]

In northern California, Professor Davidson of the U S. Coast Survey, as cited by Spencer, reports three submarine valleys about 25, 12, and 6 miles south of Cape Mendocino, sinking respectively to 2400, 3120, and 2700 feet below the sea-level where they cross the 100 fathom line of the marginal plateau. If the land here were to rise 1000 feet, these valleys would be fjords with sides towering high above the water, but still descending beneath it to profound depths.[3]

Farther to the north, Puget Sound and the series of sheltered channels and sounds through which the steamboat passage is made to Glacier Bay, Alaska, are submerged valleys of erosion, now filled by the sea, but separated from the open ocean by thousands of islands, the continuation of the Coast Range of mountains. From the depths of the channels and fjords Dr. G. M. Dawson concludes that this area had a Preglacial elevation at least about 900 feet above the present sea-level, during part or the whole of the Pliocene period.[4]

The general absence of Pliocene formations along both the Atlantic and Pacific coasts of North America indicates that during this long period all of the continent north of the Gulf of Mexico held a greater altitude, which, from the evidence of these submarine valleys, is known to have culminated in an elevation at least 3000 feet higher than that of the present time. Such plateau-like uplift of the whole continent appears to have exerted so great influence on its meteorologic conditions, bringing a cooler climate throughout the year, that it finally became enveloped by an ice-sheet to the southern limit of the glacial striæ, till, and moraines, stretching from Nantucket and Cape Cod to New York, Cincinnati, Saint Louis, Bismarck, and thence westward to the Pacific somewhat south of Vancouver Island and Puget Sound. The thickness of the ice-sheet in the region of the White Mountains and the Adirondacks was about one mile; and Dana has shown, from the directions of striation and transportation of the drift, that its central portion over the Laurentian highlands between Montreal and Hudson Bay had probably a thickness of fully two miles. In British Columbia,

[1] Smithsonian Contributions to Knowledge, vol. xv. pp. 163, 164.
[2] Bulletin of the California Academy of Sciences, vol. ii. 1887, pp. 515–520.
[3] *Id.* vol. ii pp. 265–8.
[4] Canadian Naturalist, new series, vol. viii. pp. 241–248, April, 1877.

according to Dr. G. M. Dawson's observations, it covered mountain summits 5000 to 7200 feet above the sea.[1]

While thus heavily ice-laden, nearly the whole glaciated area sank below its present level, but for the most part only to a slight amount in comparison with its previous elevation. Beginning at a line drawn north-eastward through New York, Boston, and Nova Scotia, the extent of the submergence of the land by the sea at the time of recession of the ice-sheet, as shown by fossiliferous marine deposits overlying the till, increases from 150 and 225 or 230 feet on the coast of New Hampshire and Maine to 520 feet at Montreal; 300 to 500 feet on the country south-west of James Bay; and about 1500 feet, according to Dr. Robert Bell, at Nachvak on the eastern coast of Labrador. In British Columbia, including Vancouver Island and the Queen Charlotte Islands, Dr. Dawson finds evidence of submergence to the amount of 200 or 300 feet while the glacial conditions still endured. During Postglacial time the Atlantic and Pacific coasts have been again uplifted, attaining generally a somewhat greater height than now, the most recent movements being mostly subsidence. But in the basin of Hudson Bay, and probably also in Labrador and northward, the uplift from the glacial depression is still in progress.[2]

In the interior of the continent, the northward ascent of the beaches of the glacial Lake Agassiz shows that the differential uplift attending the departure of the ice-sheet amounted to about one foot per mile, increasing from south to north or north-north-east, in the Red River Valley and the basin of Lake Winnipeg, for 400 miles from Lake Traverse to the north end of Duck Mountain.[3]

On account of the same upward movement, the beach formed by Lake Ontario when it was dammed on the north-east by the receding ice upon the area of the Adirondacks, the Thousand Islands, and the Ottawa basin, is found by Gilbert to have an ascent of three feet per mile north-eastward about the west end of this lake and along its south side, with increase to four or five feet per mile about its east end. The Postglacial tilting of the old beaches of Lake Erie, and similar changes that have been studied by Chamberlin in Wisconsin between Lakes Michigan and Superior, seem to present less regularity, probably because the restoration of equilibrium of the earth's crust is combined with independent crustal movements and strains, whereby a large part of the glacial depression of the basins of these lakes is still retained. The beaches and deltas of a small glacial lake in the valley of the Contoocook River, New Hampshire, have a northward rise of about five feet to the mile

[1] Geol. Mag. Dec. III. Vol. VI. 1889, pp. 350–2.

[2] For a more detailed review of these Postglacial oscillations, and of Quaternary movements of uplift and subsidence in other parts of the world, both in glaciated and unglaciated regions, see Prof. G. F. Wright's "Ice Age in North America," 1889, Appendix by Warren Upham, pp. 573–595.

[3] Geol. Mag. Dec. II. Vol. X. 1883, pp. 427–8; Dec. III. Vol. IV. 1887, pp. 344–8; Vol. VI. 1889, p. 37. Geology of Minnesota, vols. i. and ii. Bulletin 39, U.S. Geol. Survey. Geol. and Nat. Hist. Survey of Canada, Annual Report, vol. iv. for 1888–89, Part E.

along its extent of fifteen miles;[1] and the average of the differential uplift between Boston and Montreal, a distance of about 250 miles, is approximately two feet per mile.

North-western Europe also had a much greater altitude during the later part of the Tertiary era, in which Scandinavia and the British Isles suffered vast denudation, with erosion of fjords and channels that are now submerged 500 to 800 feet beneath the sea.[2] Probably many of these submarine channels are now more or less filled with the glacial drift, so that valleys originally descending continuously toward the margin of the continental plateau have become in some portions changed to enclosed basins. The maximum Preglacial elevation must have exceeded the depth of the Skager Rack between Denmark and Norway, which is 2580 feet, with a deep submerged valley running from it west and north to the abyssal Arctic Ocean.[3]

Under the weight of its ice-sheet, the glaciated area of Europe, like that of North America, sank mostly to a somewhat lower level than it now has, the maximum depression being on the coast of Norway, about 580 feet.[4] From this depression Scandinavia has gradually risen, with pauses during which beaches were formed; and the uplift of that country continues to the present day, as of the region about Hudson Bay.[5]

III.—Notes on the Bunter and Keuper Formations in the Country around Liverpool.[6]

By G. H. Morton, F.G.S.

THE Bunter and Keuper formations of the Trias are very fully developed in the country around Liverpool, and leaving out of consideration the Red Marl, both of these formations seem to be thicker there than anywhere else in Great Britain. The object of this paper is to give a few notes recording the thickness of the Trias, the structure of the various sandstones of which it is composed, and the character of the included pebbles, many of which are of local derivation.

Excavations and borings have been in constant progress for many years, so that every bed in the Trias has been exposed and on most horizons many times in succession, and it is now possible to tell exactly the strata to expect at any given depth when once those at the surface are ascertained.

The following section shows the succession and relative thickness

[1] Geology of New Hampshire, vol. iii. 1878, pp. 103–120.
[2] James Geikie, Q.J.G.S. vol. xxxiv. 1878, pl. xxxiii. "The Great Ice Age," second edition, pp. 279–284, with plates ix.—xii.
[3] Nature, vol. xxiii. p. 393, with map of submarine contour.
[4] Geol. Mag. Dec. III. Vol. VI. 1889, pp. 157, 158; Nature, vol. xxxii. p. 555.
[5] Nature, *loc. cit.*; and vol. xxxix. pp. 488–492.
[6] Read at the British Association, Leeds, September, 1890.

of each subdivision of the Bunter and Keuper derived from railway cuttings and tunnels, borings for water and coal-pits.

			Feet.
TRIAS	Keuper, 800 feet	Red Marl	400
		Keuper Sandstone ...	400
	Bunter, 1950 feet	Upper Soft Sandstone ...	550
		Upper Pebble-beds ...	400
		Lower Pebble-beds ...	600
		Lower Soft Sandstone ...	400
			2750

The whole thickness in 1863 was supposed to be about 1700 feet, and was obtained from the measurement of outcrops of the strata, but it is now proved to be 2750 feet. The Red Marl at the top of the Keuper, and the Lower Soft Sandstone at the bottom of the Bunter, however, vary in thickness from a few to 400 feet.

Microscopic Structure.

In each of the subdivisions of the Trias the sandstones present a typical character, though it often happens that some interstratified beds of a softer or harder nature occur and differ from those forming the rest of the strata. A few specimens from any subdivision will often indicate the horizon to which they belong, but it must not be supposed that a single piece of the sandstone is sufficient for the purpose.

In a series of beds of sandstone 2350 feet in thickness, excluding the Red Marl, and which vary on the same horizon in different localities, it is difficult to draw general conclusions of much value The microscopic examination, however, of a great number of specimens from many horizons in the Trias about Liverpool shows that there are five normal types, although they run, more or less, into each other.

Firstly—Coarse-grained sandstone, composed of rounded and subangular grains of quartz, larger than $\frac{1}{100}$th of an inch in diameter.

Secondly—Fine-grained sandstone, composed of rounded and subangular grains of quartz smaller than $\frac{1}{100}$th of an inch in diameter.

Thirdly—Coarse-grained sandstone, containing a great number of large grains of quartz $\frac{1}{25}$th to $\frac{1}{35}$th of an inch in diameter, like a minute conglomerate.

Fourthly—Coarse-grained sandstone, composed of rounded, subangular and crystallized grains of quartz—the crystallized faces having been deposited on the original grains after the sandstone was formed.

Fifthly—Coarse-grained sandstone, or quartzite, originally formed of rounded and subangular grains which have been united by the deposition of silica into a hard rock after the formation of the sandstone.

All these sandstones contain, in addition to the grains described, a great number of small splintery fragments of quartz down to $\frac{1}{1000}$th of an inch in diameter and so fine as to resemble dust.

In the Bunter formation, the Lower Soft Sandstone is very similar to the Upper Soft Sandstone in general appearance, but it is coarser and the average size of the grains is larger than $\frac{1}{100}$th of an inch in diameter. The chief distinction is the frequent occurrence of large rounded grains from $\frac{1}{25}$th to $\frac{1}{35}$th of an inch in diameter in a matrix of smaller ones, but they are not always present and seem peculiar to the subdivision in South-West Lancashire. Strata at Croxteth, Tarbock and Rainford belonging to the Lower Soft Sandstone contain these large seed-like grains, embedded in a coarse-grained matrix, but generally so loose that the rock has a soft sandy character. At Knowsley the grains are held together by secondary quartz and a quartzite of extreme hardness is the result. Kaolin is always present and often some mica.

The Lower and Upper Pebble-beds are formed of sandstone composed of coarse rounded and subangular worn and crystallized grains of quartz, associated with minute splintery fragments. Kaolin in the form of grains and dust forms a conspicuous portion of the rock. The typical sandstone of the Pebble-beds is almost a true grit formed of angular grains, but the angularity is in consequence of the crystallization of secondary quartz in planes and angles over the exterior of the originally rounded grains in optical continuity.[1] The hardness and toughness of the Pebble-beds as a building-stone is due to their compact and felted structure—the interstices between the grains being filled up with a fine dust of quartz and kaolin and the whole cemented together by ferric-oxide and silica. The grains of quartz are generally from $\frac{1}{50}$th to $\frac{1}{200}$th of an inch in diameter, besides a vast number of splintery fragments. In addition to kaolin, mica and a few other minerals occur.

The Upper Soft Sandstone is principally composed of small rounded grains of quartz, varying from $\frac{1}{100}$th down to minute fragments $\frac{1}{500}$th of an inch in diameter. The structure is of a loose sandy character, so that the sandstone soon disintegrates on exposure to the weather. The highest beds are coarser than the mass of the Upper Soft Sandstone, and occasional grains occur from $\frac{1}{35}$ to $\frac{1}{50}$ of an inch in diameter as at Scarth Hill near Ormskirk, Flaybrick Hill and Crown Street, Liverpool, but they are so rare that they are not characteristic of the subdivision. Kaolin is always present and usually a few flakes of mica. The finer grain of the Upper, compared with the Lower Soft Sandstone, is well shown by placing a series of specimens from each subdivision and from different localities, together, when the average finer grain of the latter is obvious.

The Keuper Sandstone varies considerably in its microscopical structure, and that near the base cannot be distinguished from that of the Pebble-beds. The lower beds of the Keuper Sandstone are composed of large, rounded, subangular grains of quartz, many of which are covered with crystallized faces of a more recent origin. Higher in the subdivision the sandstone is often formed of rounded

[1] The formation of crystals on grains of quartz in sandstone was first described by Prof. T. G. Bonney, F.R.S., in Q.J.G.S. vol. xxxv. p. 666.

grains and much resembles that of the Upper Soft Sandstone, though usually much harder. There are, however, other beds, about the middle of the Keuper Sandstone, remarkable for the large proportion of kaolin they contain and the occurrence of crystallized grains.

Although there is a difference between the quartz grains and the relative proportion of kaolin associated with them in the sandstones described, the chief distinction is in consequence of chemical changes that have altered the sandstones since their deposition.

The original felspar grains have been usually decomposed and the silica so liberated deposited in optical and crystalline continuity on the grains of quartz, while the percolation of water containing ferric-oxide produced the various shades of red and yellow, and both the silica and the iron form the cementing material with which the grains are united. The great diversity in the colour and the variegated appearance frequently seen, particularly about the base of the Keuper, and the variation in the tenacity with which the grains are held together in the Triassic Sandstones generally are interesting subjects for investigation and often very difficult to explain.[1]

Pebbles in the Trias.

The only pebbles that occur in the Bunter formation in the country around Liverpool are found in the Lower Pebble-beds, and considering the great thickness and the large area over which the subdivision occurs, the variety is by no means remarkable and very much alike in different localities. Most of the pebbles are less than an inch across and very few reach the diameter of six inches. They consist principally of white vein quartz, quartzite, and a few other rocks and minerals. Nearly all are of a round or oval form, perfectly smooth and must have come from a great distance, and most probably from the Cambrian and Silurian rocks of Central England or Scotland. Next in frequency, though relatively few, are rough pebbles and angular fragments of coarse felspathic grit, sandstone, and chert, resembling beds in the Cefn-y-Fedw Sandstone, Millstone Grit, and Coal-measures within twenty miles from Liverpool. They could not have travelled far, and may have been derived from strata at a less distance. Although it is assumed that the Coal-measures to the east and north-east were covered by the Trias, it is certain that they had been denuded about Parbold, Knowsley and much of Flintshire, before the latter formation was deposited on the Millstone Grit.

At Middle Island and Hilbre Point, near Hoylake, there are beds of breccia containing angular fragments of vein quartz, grit, and sandstone, associated with strata containing scattered pebbles of the quartzite characteristic of the Lower Pebble-beds. Similar brecciated beds occur at Little Mollington, near Chester, but the fragments are smaller than those at Hilbre. At Cuckoo Hill, near Hope in Flintshire, the sandstones and shales of the Millstone Grit are well exposed with the Lower Soft Sandstone resting against them, and the lowest beds of the latter form a breccia several feet thick of angular fragments from the underlying strata.

[1] "Iron as a Colouring Matter of Rocks," by A. Norman Tate, F.C.S., Proc. Liverpool Geol. Soc. vol. v. p. 284.

During the last three years, at the suggestion of Prof. Bonney, I collected a large number of pebbles from the Lower Pebble-beds of the Bunter and from the base of the Keuper Sandstone—selecting the following localities as those where pebbles were most abundant, viz. Eastham, Hilbre, Redstones, Hilbre Point, Pool Hall Rocks, Rainhill, Thatto Heath and Woolton in the Bunter; and Bidston Hill, Flaybrick Hill, Oxton, Wallasey and West Kirby in the Keuper.

The pebbles in the Lower Pebble-beds include many of white vein quartz and a few of a red shade. The quartzite pebbles vary considerably in colour and range from white to grey and black, and from white to pink, red, brown, and the well-known liver-coloured quartzite, but the latter is not common. Some of them are coarse and others fine-grained, and the latter usually fracture through the grains embedded in the matrix. These are felspathic grits which Prof. Bonney considers of the "Torridon Sandstone" type, and others resembling the Millstone Grit. Hälleflinta and black slaty rock sometimes with white quartz veins are frequent. Quartz-felsites occur, but generally in a decomposed condition. Sandstone like that of the Upper Silurian is frequent.[1] A single specimen of pink granite was found, and a pebble of white orthoclase with the cleavage remarkably bright and fresh.[2] A pebble of black chert and another of cherty mudstone resembling beds in the Cefn-y-Fedw Sandstone were also found. The largest pebbles measured six inches in length, and they were of both quartz and quartzite, but it is seldom that they occur so large. Small bits, large rounded lumps and thin partings of shale and marl are of frequent occurrence.

The pebbles in the Keuper Sandstone occur almost entirely about the base of the formation, but they are few in number compared with those in the Bunter. There are pebbles of white vein quartz, and a few have yellow and red stains. The quartzite pebbles are mostly white, and possess a glistening external appearance in consequence of the irregular fracture of the embedded grains, but there are some of a pink and light red shade, and others of light and dark grey. There are a few pebbles of hälleflinta, one of decomposed rhyolite, and another of quartz-felsite. A pebble of white and several of pink orthoclase showing the cleavage planes. Some indurated angular bits of red clay occur in the basement bed at Flaybrick, but few grits or sandstones have been found. The liver-coloured quartzite has not been seen in any of the localities examined. The largest pebbles found were two inches in length, and they are rare. Small bits and rounded lumps of red and grey marl are very common about the base of the Keuper.

It is remarkable that not a single pebble of the Carboniferous Limestone has been found in either the Bunter or Keuper, from which it may be inferred that the formation was not exposed at the surface during Triassic times. There is evidence that the Cefn-y-Fedw Sandstone, Millstone Grit and Coal-measures were exposed

[1] An Upper Silurian fossil, *Platyschisma*, was found at Eastham.

[2] A similar pebble in exactly the same condition was found in the Keuper at Wallasey.

to denudation during the deposition of the Bunter, as some of the angular fragments of grit and sandstone seem to have been derived from those formations.

The pebbles of the Keuper are similar to those of the Bunter formation, but the number and variety are much less. They do not seem to have been derived from the Bunter, and it is not likely that it was exposed to denudation at the time, so that the probability is that they came from the same source when the supply had nearly dwindled away and was almost limited to those of light-coloured quartzites.

A typical collection of the pebbles, including those from both the Bunter and the Keuper, was sent to Prof. Bonney who minutely examined and kindly sent me the following report thereon :—

"Many of the hard quartzites and quartzose rock (hälleflintas, grits of more than one type—sometimes felspathic) are identical with those which we find in Staffordshire. The igneous rocks (felstones chiefly) are less well preserved and seemingly less numerous, but I think I may say that they present a general resemblance to some of those found in that district. I only observe one piece which resembles 'Torridon sandstone,' and it is so small that I should not like, without microscopical examination, to assert positively that it might not be a fine-grained granite. One of the peculiarities of this grit found in Staffordshire is the difficulty which not unfrequently occurs in distinguishing it macroscopically from granite. But I have no hesitation in saying that your specimens, on the whole, appear to have been derived from the same sources as those we find in the Staffordshire district, only they are smaller and perhaps not quite so well rounded—clearly the Liverpool region was out of the course of the strongest currents.

"At first sight it seems strange that the Bunter in the Cheshire-Lancashire region should be thicker, but of finer material than in the Central Midland district. But it seems to be quite possible that, in the case of strata of fluviatile origin, the deposits, though of coarser material, may be thinner in the line of the stronger currents, because these deposits may be less continuous—just as a river keeps open its channel while raising the land on either side. If we assume a southern origin for the pebbles, we still have the difficulty of the greater thickness of the beds further from the source. One thing cannot be overlooked in speculations, viz. that quartzite pebbles, identical with those in Staffordshire, occur plentifully in the Upper Palæozoics of Southern Scotland. Similar felstones occur, but I can say no more because, when last I saw these Scotch Pebble-beds, I was not paying any particular attention to the matter."

Prof. E. Hull, F.R.S., some years ago, was of opinion that the quartzite pebbles of the Bunter were derived from those of the Old Red Conglomerate of Scotland, and the denuded tracts bordering the German Ocean.[1] More recently, Prof. T. G. Bonney, F.R.S., attributed their source to the quartzite of Ross-shire about Loch Maree, and minutely described the varieties that occur in that

[1] "Triassic and Permian of the Midland Counties," p. 60 (1869).

district, and concluded that they were exactly alike, while they differ from any English rock. He supposes that the Bunter beds of Central and Northern England may represent "the deltas of two great streams descending respectively from the north-west and the north-east, and receiving tributaries from land on either side."[1] Both Prof. Hull and Prof. Bonney agreed as to the origin of the pebbles, and that some may have been embedded in the Old Red Conglomerate, and ultimately in the Triassic sandstone. Indeed, Prof. Hull surmised that they "must have undergone a process of trituration during more than one geological period, else they would not be so invariably bereft of all angularity."

Mr. W. J. Harrison, F.G.S., ascribes the source of the quartzite pebbles in the Midland Counties to the old Palæozoic ridge in Central England, the short distance of which may account for the great number and variety of the pebbles found there.[2] Prof. Bonney, however, states that he has identified two different quartzites there, and that the Ross-shire quartzite is one of them. In 1883 Prof. Hull announced that he had abandoned the view of the North British origin of the pebbles in favour of that proposed by Mr. Harrison, and states that:—"At the time I suggested the Scottish source, I was freshly and vividly impressed with the resemblance of the reddish or 'liver-coloured' quartzite pebbles to those of the Old Red Conglomerate of the Lesmahago and other districts. But I all along felt the difficulty (on which Mr. Harrison lays just stress) that the number and age of the Bunter pebbles decrease from the Central District of England towards the North-west, which ought not to be the case if they had the origin I attributed to them. Further reflection leads me to think that the objection is fatal to the view either of myself or of Prof. Bonney, notwithstanding the microscopic resemblance which he points out to the quartzites of the Highland rocks."[3]

Mr. A. Strahan, F.G.S., is of opinion that the Bunter Sandstone "was distributed by strong currents flowing between Central England and Wales from the South, as the increasing abundance of pebbles in this direction indicates." If such were the case, the Bunter would appear to have been a delta deposit, the production of a river draining the lost Triassic lands.[4]

Conditions of Deposition.

The Permian, Bunter and Keuper formations in the country around Liverpool seem to have been deposited under somewhat similar conditions, and consist of beds of sandstone associated with frequent conglomerates, breccias, shales and marls. Many opinions have been expressed as to the relative conditions under which the formations were deposited, but that there was a gradual change from an open sea in the Permian to a contracted estuary or lake in the

[1] Geol. Mag. Dec. II. Vol. VII. p. 404 (1880), and Vol. X. p. 199 (1883).
[2] Proc. Birmingham Phil. Soc. vol. iii. p. 157 (1882).
[3] "Pebbles in the Bunter Sandstone," Geol. Mag. Dec. II. Vol. X. p. 285 (1883).
[4] "Geology of Cheshire," Journ. Iron and Steel Inst. p. 352 (1884).

Bunter and Keuper, and finally to a great salt lagoon in the age of the Red Marl, expresses the idea generally entertained. The Permian formation was evidently formed during and just after the upheaval of the Coal-measures, and the Trias seems to have originally covered them continuously over South-West Lancashire as it does now about Liverpool. Although the Permian has not been satisfactorily determined in the district, the marine character of the formation is evident from the fossils found at Bedford Leigh twenty miles to the east, and at Collyhurst near Manchester, though they seem stunted in growth as if they had lived in brackish water.

The Bunter formation is usually supposed to have been deposited in lakes or land-locked seas; but in the absence of the remains of marine organisms, it is certain that it was not formed in the open sea, and it is difficult to suppose it had any direct communication with it. It seems more probable that it was deposited along the course and formed "the deltas of two large streams, descending respectively from the north-west and north-east, and receiving tributaries from land on either side," as suggested by Prof. Bonney. These streams brought down such an enormous quantity of shifting sand that there was little chance of a plant, shell, or other organism being preserved in the sandstone. The source of the material, however, must have changed during the flow of these supposed Triassic rivers, for there was an alternation in the character of the sediment; firstly, fine-grained sand containing a great proportion of large rounded grains; secondly, sand with quartz and quartzite pebbles; thirdly, a fine-grained sand again; and sand and pebbles again finally appeared in the Keuper. It seems doubtful whether the pebbles came from the north of Scotland or from the centre of England, and consequently it is equally uncertain as to the origin of the enormous deposit of sandstone 2350 feet in thickness. The pebbles are said to be most numerous in Staffordshire, and decrease towards the north of Cheshire and Lancashire; but this seems rather doubtful, for the thickness of the Bunter becomes much greater in that direction and the pebbles more scattered. If the sand and pebbles came from the Midland counties, it is evident that the sand would be carried the furthest, that the pebbles might be gradually left behind, and that few would reach Liverpool. They may, however, have come from Scotland, down what is now the North Channel—a conclusion which seems probable from the great variety of the quartzites. Pebbles and angular fragments of Carboniferous rocks are common and cannot have come any great distance, and it seems probable that much of the sand came from the same source.

The rounded seed-like grains, like blown sand, have been suggested as indicative of desolate wastes, though this would only apply to the early part of the Bunter, and nothing is really known of the condition of the land bounding the supposed Triassic river, or of the source of the sand. The large smooth grains supposed to have been rounded by the wind are just as likely to have been worn by water, on account of their large size.

The Keuper formation consists of beds of sandstone and marl, and the lower part is sometimes so like the Pebble-beds of the Bunter that it is difficult to distinguish one from the other in the absence of an extended section, showing the relative position of the formations.

The Keuper has fewer pebbles, but thicker beds of shale and marl. The general opinion is that it was deposited in a series of lakes, for no fossils indicating marine conditions have been found, and locally only a few land-plants at Flaybrick and Storeton. There were shores or banks of sand and clay, and the occurrence of ripple-marks, rain-marks, sun-cracks, worm-tracks, and foot-prints indicate changes that might be expected in such situations.

In the Red Marl there is abundant evidence of a salt-lake or lagoon, and the continuous evaporation is obvious from the thousands of pseudomorphic crystals of chloride of sodium that cover the surfaces of shaly beds in the lower portion, while in Central Cheshire thick beds of rock-salt afford evidence of the entrance of sea-water and the subsequent precipitation of the salt. These conditions must have continued for a long period, and it is quite possible that the surrounding country may have been of the desert character that some geologists suppose, though there seems very little to support such a conclusion.

The whole of the Triassic strata were deposited in a subsiding area, but there is no reason to suppose that the water was deep, for the frequent presence of current-bedding indicates shallow-water conditions. It may be remarkable that subsidence should accompany deposition, but if there were no subsidence it is difficult to conceive how deposits of great thickness could be formed in lakes or near the land, for the sediment would be spread further out over the shallow sea-bottom. Dr. C. Ricketts, F.G.S., is of opinion that the increasing weight of the sediment is the cause of the subsidence, but it is just as easy to suppose that where a great thickness of strata occurs, it is in consequence of a long-continued subsidence from some other cause which rendered the great accumulation possible.

IV.—On the Nature and Origin of the Banded Structure in the Schists and other Rocks of the Lizard District.

By Alexander Somervail, Esq.

Introduction.

In my last communication, "On the Schists of the Lizard District," published in this Magazine for April, which was meant as preparatory for the present paper, my object was to show that the rocks known as the "talco-micaceous," "hornblendic," and "granulitic" groups were of true igneous origin, also plutonic ? and had been formed out of a common, but complex magma, and that all of these groups were made up of rocks differing widely from the types of each of them, which in some instances were seemingly due to differences in the rate of cooling, and to chemical affinity ; and yet again in other instances to subsequent mechanical movements and pressure during or after consolidation.

Although I provisionally cancelled one of these three groups, the "talco-micaceous," my doing so, as I then stated, would not materially affect the reasoning in that paper, neither will it do so in the present, even if I should be wrong on this point.

The gist of some of my remarks was also meant as introductory to an attempt in the present paper to show that the origin of the banded structure pervading certain of these Lizard rocks might be explained on the ground of segregation, before or during the cooling of the common magma out of which they seemingly had been formed. The fact alone of this magma giving rise to such a diversity of rocks which, although in certain parts of the field isolated from each other, are yet in other parts not only associated and blended together in a somewhat massive way, but in other districts are mingled with each other on a much smaller scale, and with a greater degree of symmetry, so as to pass by easy transition into what is properly termed the banded structure. These facts alone of themselves seem to supply an intelligible basis, or starting-point, for an explanation of this phenomenon—of course confining the term "banded" to those more strictly symmetrical portions of this structure now to be described.

I. Nature of the Banded Structure.

Although this paper is principally confined to the banded structure in the rocks included in the triple or double group of schists and rocks, it may yet embrace all the other rocks of the area, as all of these are more or less banded in one form or another, and the same explanation seems to me to serve for the whole, in the wide and proper sense of the term.

In the double group of schists (and rocks), viz. the "granulitic" and "hornblendic" (between which I have divided the talco-micaceous) are rocks with a wide variation in their banded structures, especially in the granulitic group. In this group it assumes many different forms, ranging from well-defined banding of a more or less regular and persistent horizontal type, to highly irregular bands thinning and swelling out again. At other times the bands are lenticular and run in an oblique direction, and even the materials which form the banding in the base of the rock are sometimes found in isolated patches without any visible connection between them. General McMahon has given a very succinct description of the banding in this group which is as follows: "The rocks of this group are usually spoken of as a banded group, and appearances often support the idea that the quasi-banding is a regular banding parallel to the bedding. When the eye of the observer becomes accustomed to these rocks, however, the banding is seen to be extremely irregular in character. Not only do some of the bands dwindle into strings and die out in the direction of their length, but they inosculate, bifurcate, and entangle themselves into a complicated network of meshes, and they swell in places into broad lacunæ, which, in their turn, throw off fine veins in all directions. Even where these bands are apparently most regular, they will often be found, when followed up, to behave like injections."

My own observations on the nature of the banding I shall now give from a few typical localities, copied from notes as I made them on the spot.

Kennack.—The banded granulitic rocks here consist of a dark basic, or diorite portion, and an acid or granitic one which greatly predominates, varying much in texture and composition, ranging in colour through pinkish-white or grey, to pale red, dark red, and brown. Sometimes these acid or felspathic bands are themselves banded with paler and darker portions of their own composition, thus forming a distinct inter-banding of their own. Sometimes the lines of demarkation between the diorite and granitic bands are of the most perfect nature, but this is not always so, as they frequently pass over into each other by the finest gradations. Besides the intermingling of both of these rocks in the dykes cutting the serpentine of the cliff here, I have noted the fourth dyke west from Kennack as exhibiting a good example of banding in a dyke. The first dyke is also a good instance.

Caerleon and Little Coves.—In both of these coves banded granulitic rocks occur. The most notable feature is at Little Cove, where there is a type of the granulitic not of a very granitic texture, of a reddish colour, rather slightly and confusedly banded, not by dark diorite bands, but by paler and darker shades of red of similar composition to its base. South of Caerleon Cove there are pale felspathic varieties banded with still paler bands of felspar. Both of these varieties occur elsewhere.

Kildown Cove.—Here there are great masses of reddish granulitic rock without any banding whatever, which, however, at some distance off becomes dioritic and banded in the usual way. Here is the rudely circular mass of rock already referred to,[1] made up of the concentric layers of diorite and granulitic, with the latter for its centre.

Flag-staff Quarry, Kildown Point.—The banded structure can here be studied in many of its varieties. The banding in places is of a regular and persistent character, fining down to alternate parallel lines of dioritic and granitic minerals as thin as a sheet of paper, or in broader bands composed of hornblende and felspar mingled together. Highly irregular and lenticular banding also occurs, and in some of the diorite bands are small elliptical masses of the granitic portion, quite isolated from each other. At the top of the quarry where these rocks may be seen (seemingly) cutting through the serpentine, the banded structure is still traceable, but on a smaller scale, and much more confused, the mass of the rock also being modified from its contact with the serpentine.

The Balk.—Here the banded "granulitic" rocks are in great force, consisting principally of the acid and felspathic type, the dioritic portions being very subordinate in comparison to the other. These quartzo-felspathic and granitic rocks are highly banded, not so much with bands of diorite as with portions of their own composition of various textures and colours, according as they consist of felspar

[1] Geol. Mag. Vol. VII. p. 166 (1890).

more or less pure, or mixed with quartz, more or less granitic; the paler shades consisting of the former, the darker of the latter.

Trelease Moor.—The rocks here, which I referred to in my last paper as rising through the serpentine, and as formed of several distinct varieties of rock, ranging between the dioritic and granitic types, I have found in a recent visit, also, to be most distinctly banded, the granulitic bands passing gradually into the more basic portion of the rock.

Although the banded structure exists in the granulitic rocks on the south coast, near the Lizard Head, and in the outlying reefs, and at the Yellow Carn, also on the west coast at George's Cove, yet it presents no special features beyond what has already been noted in the foregoing localities.

In the "hornblende" group the banding is of a much less complex character, the bands of whatever minerals they may be composed having as a rule a linear arrangement. They generally consist of alternations of felspar and hornblende, the latter more pure and granular or crystalline than the base of the rock, the former also differing much in its exemption from other minerals, and likewise in its colours. The felspar bands are not always uniform and parallel, but frequently occur in lenticular patches, and display other irregularities. In thickness they vary from the thinness of a sheet of paper up to bands of a couple of feet or more as at George's Cove. There are also numerous bands of epidote, but they are only to be regarded as an alteration product of the hornblende. Besides the parallel banding in the hornblende group there is another type of less regular banding, gradually becoming more so until the arrangement of the bands are lenticular and the rock in appearance like a well-foliated gneiss.

These gneissose rocks can be studied at the base of the old Lizard Head, and the outlying rocks; also, in those of the Dranna rocks which lie immediately off Porthkerris Point, east of Porthallow.[1] Others of a similar nature have been described by Mr. Howard Fox, on the fore-shore south of Ogo Dour Cove.[2]

II. Origin of the Banded Structure.

It is a remarkable fact that all the great distinctive varieties of rock in the Lizard district exhibit more or less of a banded structure. As is well known, it is present in the gabbro, and even the serpentine is not free from it.[3] A good example of very distinct banding may be seen in the green serpentine of Kildown Cove, and I have noted a similar banding in other localities, over and above the distinct thin layers, or bands of nearly pure hornblende which traverse, even, the true serpentine as at Gue Graze.

[1] The gneissic rocks from both of these areas were shown me by Mr. Howard Fox, F.G.S. In the latter locality I would not have suspected them to occur.

[2] Junction of the Hornblende Schist, etc., Trans. Roy. Geol. Soc. of Cornwall, 1889, vol. xi. part iv. p. 213.

[3] *Vide* paper by Mr. Rutley, Trans. Roy. Geol. Soc. Corn. vol. ix. part 4, 1889, pp. 239–241.

The origin of the banded structure in the "granulitic" and "hornblende" group of rocks in this district has been accounted for in three separate ways by sedimentation, deformation, and by injection.

Sedimentation.—This explanation was very naturally and consistently given by Prof. Bonney on the ground of the rocks being thought by him to be of sedimentary origin. There are, however, certain arrangements in the banded structure of the "granulitic" group which no false bedding could produce, or even simulate. These arrangements of structure I have already given as quoted from General McMahon, and I have myself also noted other appearances such as the numerous fine thread-like processes and broader ones, which cross at various angles from the one band to the other.

If, on the other hand, these rocks are of igneous origin—as I believe them to be—then we must seek for some other cause to explain their banding, even allowing that some of them were originally ashes, altered and deformed by subsequent dynamical causes.

Deformation. — Mr. J. J. H. Teall, M.A., F.R.S., F.G.S., has advanced this theory and has applied it both by observation and experiment in a clear and able manner. He regards a large portion of the rocks at least forming the 'granulitic' group as a complex of igneous rocks partly dioritic and granitic, deformed by dynamic causes, during, or subsequent to their consolidation. This theory (if I mistake not) not only pre-supposes, but points to the existence of heterogeneous masses of these rocks in the field which were the raw materials out of which the banded structure was wrought by subsequent dynamic agencies, which kneaded them more completely together, and produced the secondary results of banding as now exhibited. If this theory is confined to the mere mechanical movement of the rocks without the aid of their partial re-fusion and the consequent effect of chemical agency, it seems to me very hard to explain much of the phenomena presented by the banding as we see it in the field. The subsequent movements might, and I believe do account for much of the eccentricities exhibited by the course of the bands, such as the flexures and zig-zag features occasionally observed, along with other signs of deformation, which has modified but not produced this structure. This theory also seems to account for the quasi-banding in portions of the "hornblende" group, such as the thin deposits of felspar, epidote, etc., developed between the cleavage-planes of the schistose varieties of these rocks, but, to account for the normal or true banding when it does occur, it seems almost powerless.

The principal objections to this theory presenting themselves to my own mind, as far as the "granulitic group" is concerned, are as follows:—

1. The seeming inability of deformation to produce out of an igneous complex the symmetry frequently prevailing in the banded structure. This symmetry consists of the very parallel arrangement of the various bands exhibited in some localities; one band of diorite

and another of granulitic materials alternating with each other, often with much uniformity, in their respective thicknesses, and this too continued over considerable areas.

2. This theory does not explain the frequent transition of these bands into each other, which, although comparatively distinct and well-defined from each other in some areas, and portions of the same mass of rock, are nevertheless, in others, marked by a passage of their mineral constituents.

3. The theory does not explain the banding—most frequently parallel—in those masses of nearly homogeneous granulitic rocks, where the banding is entirely made up of the slightly varying quartzo-felspathic mineral constituents which form them, and not of the widely contrasted bands of dioritic and granulitic minerals; these rocks not coming under what is designated as an igneous complex.

Injection.—This theory has been advanced by General McMahon more particularly to account for the banding in the "granulitic" group, a group, as already stated, considered by him to be made up of volcanic ashes and lavas, into which have been intruded diorites and subsequently other porphyritic diorites, and by granites still later, each in its turn injecting the other. It is, however, to the last of these, the injection of the granite, that, according to General McMahon, the banding is due, or mainly due, at least it is made the prominent factor in his explanation. He remarks that, "the process of injection was doubtless aided by the partial plasticity of the dioritic rocks—a plasticity induced probably by the neighbourhood of igneous masses, for it seems to have been local in its development. It would also have been aided in the case of consolidated ash-beds—especially in submarine ash-beds—by the planes of sedimentation, and in the case of diorite intruded as sheets by the foliation developed in a direction parallel to the bedding. The existence of such planes of weakness would explain why the injected granite displayed a tendency to follow lines parallel to the bedding, and in doing so produced the superficial appearance of banding."

This explanation of General McMahon's certainly much better meets the difficulty or objection just urged against Mr. Teall's views, which afford no explanation of the symmetry of the banding, to which attention was drawn; indeed, according to the theory of the latter (if I understand it aright), it would be entirely destructive of this parallel or symmetrical structure, and not the cause of it.

As a whole, however, the "injection" theory seems to me to fail even in the one direction in which it has been applied, while it offers no adequate explanation of the banded structure in a general sense.

To whatever cause, then, the banded structure may ultimately be assigned, I think it sufficiently clear that all of these three modes of explanation completely fail when applied to these Lizard rocks. First, the sedimentary, because it is at once negatived by the igneous origin of the rocks in question, no tuffs as yet having been recognized. Second, the deformation theory, because it never could produce the linear arrangement or parallel structure as we find it in both (what I may term) the heterogeneous and homogeneous granulitic masses. Although I must admit such an arrangement can (to a certain extent) be produced by pressure exerted on clays, as described by Mr. Teall, by artificial means, but not to meet all the facts as presented in the field. Third, the injection theory, because even in the solitary instance in which it can be applied, the parallel bands of diorite and granite show no decided signs of intrusion into each other.

III. Due to Segregation.

The only theory which to my mind seems to explain the banded structure in these Lizard rocks is segregation. (By this term I mean the separation of the unlike, and the union of like mineral constituents taking place during their cooling.) It seems to me to satisfy all the different aspects of their banded structure; and these, as already stated, present a considerable variety of more or less distinct types, some of them so palpably due to this cause that in my field notes, made during a number of years, I have again and again the word "segregation" written against the description of these banded rocks.

If I can succeed in showing—as attempted in my former paper—that the varieties of dioritic and granulitic rocks were differentiated out of a common magma, then it would seem to follow that such a separation on a smaller and less perfect scale, under conditions to which the term segregation might be more properly applied, would produce such a result as the banding in all its varied aspects.

The proofs already given of such a separation need not here be again recapitulated; but to those proofs might be added the fact mentioned by Mr. Howard Fox and myself in a joint paper[1] that the hornblendic and felspathic lines circle round the porphyritic crystals of felspar in the dark or dioritic bands of the granulitic series. These lines must have so arranged themselves after the cooling of the felspar forming these crystals, which, besides being an excellent proof of the segregation of these mineral constituents from the common magma, is also a convincing one of the igneous origin, and, let me add, also of the plutonic origin of these rocks.

Besides these facts, I have already drawn attention to others bearing out the important part that segregation has played in these Lizard rocks, in my short paper "On the Greenstone and Associated Rocks of the Manacle Point,"[2] which seems to afford the only possible explanation of that area.

Still further, in my last communication, already referred to (p. 166), I drew attention to a concretionary mass of granulitic rock at Kildown Cove composed of concentric layers of dioritic and granulitic minerals, which is simply the banded structure in a rudely circular form produced by segregation. This mass is certainly not the product of an original and an intruding member, but clearly the

[1] Geol. Mag. Dec. III. Vol. V. p. 77.
[2] Geol. Mag. Dec. III. Vol. VI. p. 425.

product of one cooling mass arranging and separating itself into distinct layers as before described.

An excellent instance of what I regard as segregation bands in the hornblende group may be studied in a large boulder resting in the small cove immediately to the west of Lower Balk Serpentine Quarry. This mass presents a parallel banded structure made up as follows. There are broad and narrow bands of nearly pure pale-coloured felspar alternating with thinner bands of nearly pure dark hornblende more crystalline than the base of the rock. What looks at a little distance like other broad bands of the pale felspar are found on closer inspection to be made up of very thin deposits of that mineral set closely together, some of which are not persistent for a small space, but are again continued without any interruption in their parallel course. At intervals along with these are bands of varying width of the ordinary hornblende, some of which are highly porphyritic, the long axis of the felspar crystals being parallel to each other, and in the direction of the bands themselves, as if that mineral in places was not sufficiently abundant to be drawn out into the form of continuous bands.

All these varieties of banding in this one mass of the hornblende series was most convincing to my mind that the felspar had arranged itself, as also the more crystalline hornblende, by segregation during cooling.

Some of the difficulties in the way of an explanation of the banded structure, pointed out by General McMahon, such as where in some instances the bands "inosculate, bifurcate and entangle themselves into a complicated network of meshes," and in other cases given by myself where filaments or thread-like processes, and broader strings, cross at various angles from one band to another, are all readily enough explained on the grounds of segregation while the mass of the rock was in a molten or plastic state, admitting of the various movements of its several constituents.

The banded structures in the gabbro and serpentine are equally well accounted for by segregation, while on the ground of deformation it is barely possible, more especially in the latter rock.

IV. Concluding Remarks.

Although we are quite unaided, as far as I am aware, by the results of any experiments such as might be made by melting the basic and acid rocks together, as, for example, diorite and granite, and allowing the molten magma slowly to cool again, in order to ascertain what arrangement its several constituents might take, effected no doubt by their different cooling points, chemical affinities, and specific gravities, still, we can infer from reflection, and from certain rocks presented to our observation in the field, that under certain conditions, such as unequal and different rates of cooling of the various mineral constituents, abnormal forms of crystallization would arise. That these and other conditions would produce various structures such as the separation by segregation of the various minerals in masses of more or less definite arrangement is quite apparent. The parallel or banded structure, a priori, would be as likely a one as any.

Dr. Sterry Hunt, in contributions to the American Journal of Science for March and July, 1864, gives several instances of banding in rocks which, according to his own descriptions, seem to me to be due to segregation. Describing a granitoid dolerite at Mount Royal, he says it consists of "Mixtures of augite with felspar in parts of which the felspar predominates, giving rise to a light greyish rock. Portions of this are sometimes found limited on either side by bands of nearly pure black pyroxenite, giving at first sight an aspect of stratification. The bands of these two varieties are found curiously contorted and interrupted, and seem to have resulted from movements in a heterogeneous pasty mass, which have effected a partial blending of an augitic magma with another more felspathic in its nature." In another communication by the same author to the Boston Society of Natural History, January 7th, 1874, he describes an eruptive diorite from Lambertville, New Jersey, "which is conspicuously marked by light and dark bands due to the alternate predominance of one or the other of the constituent minerals." The same author, again, in his "Chemical and Geological Essays" (Granites and Granitic Vein-stones), gives instances of a banded structure in granites, and granitic dykes. All of which instances can only be explained I think by segregation.

While regarding what I would term the normal or true banding as of segregation origin, I do not wish to overlook what I myself believe to be a fact, viz. that certain types of the banding in some of these Lizard rocks are due to subsequent causes, the product of severe mechanical pressure or crushing. Such banding, or perhaps more properly speaking, foliated structure, as occurs among some of the hornblende schists, and also in certain portions of the gabbro, I think may be due to this cause; but, after all, this is still the product of segregation, secondary segregation we may call it, produced by the heat being sufficiently great to admit of partial fusion, and of certain of the minerals in a greater or lesser degree to re-arrange themselves. Under these circumstances secondary segregation would seem to me to give rise much more readily to certain forms of lenticular foliated structure, rather than to the parallel banded structure proper, which I think is due to original, or primary segregation, while the rock was in a complete state of fusion.

There are other forms of what might be spoken of as banding, which, however, are only pseudo-bands which seem merely due to the development of secondary or alteration products between the planes of cleavage, such as are frequently met with in the hornblende schists. These and certain other similar types more properly fall under the term cleavage foliation, rather than under that of banding.

V.—Suggestions on Sites for Coal-search in the South East of England.[1]

By W. Whitaker, B.A., F.R.S., F.G.S.

THE general question of the rise of older rocks beneath the Cretaceous beds of south-eastern England is now so familiar to geologists that there is no need to discuss it here: it is enough to note that the Secondary beds (beneath the Gault) thin northward, for many miles, from the axis of the Weald. The practical application of our knowledge of the subject is however in its infancy, and our knowledge stops short at the Wealden axis; for we do not know what happens south of it.

Having regard to the great expense of making the deep trial-borings that would be needed in the search for coal in this district, it is clearly well, as far as possible, to select sites where a good amount of the work has been already done. The object of this note is to point out that there are such sites, and that they are favourably placed for the search.

These sites will be noticed beginning at the south-east, near the only place where coal has yet been proved in the large tract in question, and working thence westward and northward.

1. *Saint Margarets.* About 4½ miles north-eastward of the boring that has shown the presence of coal underground near Dover, is a trial-boring, made by the former Channel Tunnel Co., which reaches the Gault at the depth of 548 feet. Presuming that the beds beneath are the same as at Dover, a further depth of say about 900 feet (in the absence of precise information) would be needed to show whether coal is present or not; but as, on the southern side of the London Basin, the thinning of the beds between the Gault and the older rocks is in a northerly direction, we should expect that there would be less of these beds at St. Margarets than at Dover.

It is remarkable that whilst at the Dover trial-boring no Wealden beds were found, another boring, at the Convict Prison, a little to the north-east, seems to have reached beds of that age, at the depth of 849 feet. A continuation of this boring would of course be of interest, though the site is near that of the successful trial.

2. *Chartham.* Some three miles south-westward of Canterbury another boring has reached the same horizon, having touched the Gault at the depth of 735 feet, and here probably the beds between the Gault and the older rocks would be much thinner than at Dover.

3. *Chatham.* A boring at the Dockyard has given us much more information than either of the above, for it has reached the bottom of the Cretaceous Series at the depth of 943 feet, and has been carried 22 feet in Oxford Clay. Seeing that at Dover all the three divisions of the Jurassic Series are represented, and that at Chatham the whole of the Upper Jurassics and part of the Middle Jurassics are absent,

[1] A paper read to the Brit. Assoc. at Leeds, and printed in the *Yorkshire Post* (and other newspapers), and in the *Brighton Magazine* (October, 1890). Some slight additions and corrections are now made.

it is clear that at the latter place we have much less of that series to contend with than at the former. Moreover, it is likely that the rest of the Middle and the Lower Jurassics will share in the thinning and will be of less thickness than at Dover. It seems to me that the Chatham boring should certainly be continued, as a deepening of a few hundred feet would probably show which of the older rocks there comes beneath the Secondaries. Moreover, the site and the land around belong to Government, as also does a neighbouring boring, at Chattenden, which has reached the base of the Gault at the depth of 1162 feet; so that a successful result would benefit the nation.

4. *Shoreham* (Kent). A well here, in the valley of the Darent, has gone 26 feet into the Lower Greensand, with a total depth of 475 feet, comparatively little Chalk being present.

In Surrey, at Caterham and at East Horsley, are two borings, to the same depth, 874 feet; but whilst the former has been carried a little way into the Lower Greensand, the latter has done little more than reach the Gault. I am inclined, for the present, to pass these by, and to turn to the northern side of the London Basin, from west to east.

5. *Bushey* (Herts). A boring here has been taken nine feet into the Gault, at the depth of 700 feet; but, being at a waterworks (as also is that at Caterham), it probably could not be touched. The knowledge of what would be found here a few hundred feet further down would be very useful, and possibly less than 200 feet would reach the base of the Secondaries.

6. *Loughton* (Essex). Here a boring has found water, apparently at the base of the Gault, at the depth of little less than 1100 feet, from which one infers that Lower Greensand may have been touched. It would be well, however, for inference to be supplanted by knowledge.

We do not know what beds were found in the bottom part of another Essex boring, at Saffron Walden, which reached to a depth of a little more than 1000 feet. By inference they are Jurassic, the earlier accounts having given much too great a thickness to the Chalk. Here again inference is not enough.

7. *Coombs*, near Stowmarket (Suffolk). A boring, 895 feet deep, has here pierced 11 feet of Gault. Judging from what was found at Harwich, some 20 miles S.E., it is not likely that a much greater depth would be needed to reach some member of the older rocks, and, as at Harwich the bottom-rock is Lower Carboniferous, it is to be hoped that further work may be done in that neighbourhood.

The more northerly boring at Norwich is too far from our base (of knowledge already gained), and that at Holkham, near Wells, at the northern edge of Norfolk, is still more so, besides being no very great distance from the outcrop of thick Jurassic beds.

Further examination of our great stores of well-sections would perhaps result in the selection of many other sites at which much of the work is already done; but in the above remarks only such borings as have been carried beneath the Chalk are referred to.

A full account of the history and literature of the question of the underground range of the older rocks in the South East of England, especially as regards the possible occurrence of Coal Measures, has been given in lately published Geological Survey Memoir, "The Geology of London and of Part of the Thames Valley."

VI.—On Pre-Cambrian Rocks Occurring as Fragments in the Cambrian Conglomerates in Britain.

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

(Read at British Association, 1890.)

Of late years the Cambrian Conglomerates have received a considerable amount of attention, as it has been shown that much information concerning the nature and condition of the Pre-Cambrian rocks can be obtained by the careful examination of the materials composing the conglomerates in different areas. It is evident that rocks similar to the rolled fragments in the Conglomerates must have been present in pre-Cambrian times to yield these fragments, and if in certain areas special rocks occur abundantly or otherwise, the characters of the pre-Cambrian rocks in these areas may be to a great extent determined. The Cambrian Conglomerates in Wales and Shropshire have been very carefully examined by Prof. Hughes, Dr. Callaway, and myself, and the materials collected have been submitted to Prof. Bonney and Mr. T. Davies for microscopical examination. These eminent petrologists have from time to time described the results of their examinations and have shown most conclusively that certain fragments which occur in the Conglomerates are in the minutest particulars identical with rocks which have been claimed by us, in the areas in which the Conglomerates occur, as being of pre-Cambrian age. In some areas the Conglomerates have been found to be composed almost entirely of materials from rocks, which can clearly be shown to underlie them, and the special characters recognizable in the rocks below are found in the rolled fragments in the Conglomerates which rest unconformably upon them. I have endeavoured to indicate by a table the contents of the basal Cambrian Conglomerates in Britain in several of the areas where it has been claimed that pre-Cambrian rocks are now exposed, and an analysis of this table is in many ways very suggestive. It is found that certain rocks occur in each of the areas, whilst others are limited to those districts where special rocks are known to characterize the pre-Cambrian series. In the first column I have given the rocks which I have collected in Pembrokeshire, and these are, in the main, very similar to those which have been collected in N. Wales and Shropshire. Those mentioned from Ross and Sutherland have either been collected by myself, or are mentioned in papers by the officers of the Geological Survey. The Cambrian Conglomerates near St. David's, Pembrokeshire, have perhaps received more attention than those of any other area, and the notes furnished by Prof. Bonney and Mr. T. Davies prove in the

TABLE SHOWING THE ROCKS WHICH HAVE BEEN FOUND IN THE CAMBRIAN CONGLOMERATES IN DIFFERENT AREAS.

ROCKS.	Pembroke-shire.	Merioneth-shire.	Carnarvon-shire.	Anglesey.	Shropshire.	Ross-shire.	Sutherland-shire.
Granitoid (granite, pegmatite, etc.)	x	x	x	x	x	x	x
Quartz-porphyry ...	x	...	x	x	x		
Felsite	x	x	x	x	x		
Rhyolite, dacite and andesite	x	x	x	x	x		
Diorite and syenite ...	...	...	...	...	...	x	x
Diabase and basalt ...	x	x	x	x	x	x	x
Gneiss	...	...	...	x	x	x	x
Sericite-schist	x	x	x	x	x	x	
Chlorite-schist	x	x	...	x	x	x	
Hornblende-schist ...	...	...	...	x	...	x	x
Mica-schist	x	x	x	x	x	x	x
Quartz-schist	x	x	x	x	x	x	x
Volcanic fragmental (acid and basic)	x	x	x	x	x	x	x
Porcellanite	x	x	x	x	x		
Clay-slate	x	x	x	x	x	x	x
Quartzite	x	x	x	x	x	x	x
Sandstones	x	x	x	x	x	x	x
Calcareous	...	...	...	x	...	...	x
Ferruginous	x	x	x	x	x	x	x
Quartz, jasper, etc. ...	x	x	x	x	x	x	x

most conclusive manner that some peculiar granitoid rocks, basic and acid volcanic rocks, schistose rocks, porcellanites, and argillites, similar to those which are found in the pre-Cambrian axis, occur as rolled fragments in the overlying Conglomerates. As these fragments are now, in all important particulars, identical in character with and can be shown to have suffered all the mineralogical changes which the rocks from which they were derived had undergone before they were broken off, it is perfectly evident that not only must there have been a considerable lapse of time, separating the Cambrian from the pre-Cambrian, but also that during that interval the area must have been subjected to very important physical changes. The following places may be mentioned as offering important evidence in support of the above views. At Ramsey Island, and Treffgarn in Pembrokeshire, at Bangor, and near Llanberis and Bethesda in Carnarvonshire, where the Cambrian Conglomerates rest on felsites and old rhyolites, more than three-fourths of the pebbles, which are frequently of very large size, have been derived from the immediately underlying rocks. Near St. David's, and at other places where the conglomerates rest on various altered volcanic tuffs, a large proportion of the pebbles have been derived from those tuffs after they were cleaved and otherwise changed into their present condition. At Porthclais, Chanter's Seat, and Port Melyn near St. David's a large number of the pebbles (mostly of small size) and the mixture of broken quartz and felspar of which some of the beds are almost entirely composed, could only have been derived from the underlying granitoid rocks (Dimetian). Near Llanfaelog and Llanerchymedd in Anglesey, very large pebbles of the underlying granitoid rocks are abundant in the overlying Cambrian Conglomerates and at Twt Hill, near Carnarvon, the matrix and many of the pebbles must undoubtedly have been derived from the underlying granitoid rocks.

The so-called Torridon conglomerates and sandstones in Ross and Sutherland contain abundant evidences to show that most of the materials were obtained from the rocks upon which they now rest, after the latter had assumed their present condition.

The presence of pebbles of granitoid rocks, quartzites, quartz-schists, etc., in all the areas proves clearly that some granitoid rocks were exposed to denudation on a large scale in many areas, in very early pre-Cambrian times; for materials derived by denudation from the latter rocks must have been formed into quartzites, porcellanites and schists (Arvonian rocks) in early pre-Cambrian times. By subsequent denudation these yielded pebbles to the newer pre-Cambrian rocks (Pebidian) and afterwards to the basal Cambrian conglomerates. I maintain therefore that the pre-Cambrian rocks contain evidences of successive periods of elevation and depression, and probably of volcanic activity, and that the tendency of the evidence is undoubtedly to show that some granitoid rocks, such as those we have classed in Wales under the name Dimetian, are amongst the very oldest of the pre-Cambrian rocks which are now found exposed, and that some quartzites, porcellanites and schists occupy an intermediate position in point of age between these granitoid rocks and the Pebidian series. The pre-Cambrian periods therefore, which I have defined by the terms Dimetian, Arvonian, and Pebidian, are easily recognizable, and seem to have succeeded one another in that order.

In my early papers I stated that the Dimetian granitoid rocks were probably of metamorphic origin. Since then I have been led to change this opinion, and to admit that these peculiar granitoid rocks of early pre-Cambrian age, exposed in several areas in North and South Wales, must have had an igneous origin. There is no evidence to show that there are any rocks of sedimentary origin in Wales which can be classed as belonging to that period. The quartzites, quartz-schists, and porcellanites found in Anglesey and elsewhere were probably derived by denudation from these granitoid rocks, and should be classed, as suggested by me in papers in 1880 and 1881, as belonging to the Arvonian period. Some peculiar acid volcanic rocks found in Carnarvonshire and Pembrokeshire belong also to this period, for fragments of these rocks, in the condition in which they are now found, occur abundantly in association with the pebbles of quartzites, quartz-schists and porcellanites in the Pebidian agglomerates.

REVIEWS.

I.—Les Enchainements du Monde Animal dans les Temps Geologiques. Fossiles Secondaires. By Albert Gaudry. pp. 523. (Paris, 1890.)

THE literature of Palæontology has been marked by a dearth of any satisfactory popular handbooks, answering to the innumerable works by which the study of Zoology has been encouraged and advanced. There have been admirable scientific text-books suited to the student, and any number of volumes discussing the relations of fossils to cosmogonies and fads; but there are very few books such as the present, sufficiently simple to be intelligible to the ordinary reader, and yet commanding the respect due to so well known and distinguished a palæontologist as Prof. Gaudry.

The work commences with a chapter on the divisions of the Mesozoic, with a tabulation of most of the palæontological zones—and in some cases "*zonules*"—of the French deposits. The bulk of the volume is occupied by an account of the various groups of the animal kingdom as developed in the Mesozoic era. These divisions are sketched shortly and simply, and the leading points in their structure and palæontological value well brought out. Thus the great variability of the Foraminifera is illustrated by a number of figures showing how *Oolina* might pass to a *Cristellaria* either through such a series of forms as *Nodosaria* and *Marginularia* on the one hand, or through *Frondicularia* and *Flabellina* on the other.

The author's principal conclusion seems to be that the corollary to the acceptance of evolution is a great simplification of palæontological nomenclature. He points out in the preface that the attempt to give separate specific names to each shade of variation would simply result in the compilation of "catalogues sans limites où l'humaine faiblesse se perdra." He repeatedly asserts that the width of specific range that is regarded as admissible in the members of any group is simply dependent on the amount of work devoted to that group. Many arguments in support of these views are scattered through the descriptive portion of the treatise. As is pointed out in the preface, the work is not a simple text-book of palæontology, but an exposition of these ideas. Nevertheless the short descriptions of the classes, and the extensive series of admirable illustrations, will enable a reader to obtain a good idea of the principal variations in any group. This is a book, moreover, which will well repay perusal by more advanced students, as it is full of most valuable and original suggestions. In fact, the most serious fault to be found with the work is the way in which new ideas are proposed without adequate illustration or discussion. Thus Prof. Gaudry's theory of the origin of the Actiniaria from the Rugosa through the Astreans, Turbinolidæ, and Perforata, is compressed with five illustrations into a page and a quarter. More space might also be devoted to the suggestion that the old naturalists were not so far wrong in allying the Foraminifera with the Mollusca;

the former, says the author, may be derived from the latter by arrest of development, which, however, has affected the soft parts more than the more simply organized shell. Though this hypothesis is advanced "with all reserve," it is so briefly and prettily expressed, that an elementary student might easily be induced to adopt it.

The preceding volume of this work, dealing with the Palæozoic fauna, was issued in 1883; the first part describing the Tertiary Mammalia was published in 1878, and has long since been out of print.

If Prof. Gaudry, instead of merely republishing that book, would prepare a similar volume to the present one, dealing with the whole Tertiary fauna, he would still further add to the feelings of gratitude that must be entertained by all who are interested in the popularization of palæontology.

In conclusion, we cannot speak in too high terms of one who has, like Prof. Gaudry, devoted his life to the exposition and illustration of palæontology, and whose numerous original researches and publications upon the fossil Mammalia of Attica, of Mont Lébéron, and other localities, have won for him the highest scientific reputation.

II.—Researches on Ripple-marks and on Wave-action. By A. R. Hunt, M.A., F.L.S., F.G.S.

GEOLOGISTS have given their attention to the subject of Modern as well as Ancient Sea-beaches, but they have not occupied themselves very much with the present state of the Sea-bottom extending from low-tide mark to 40 or 50 fathoms. Submarine researches are, however, capable of affording much valuable information to geologists, not only on the character of the rocks that may form the sea-bed beneath recent deposits, but also on the nature of the deposits now forming and the influences that affect them. For a number of years Mr. A. R. Hunt, of Torquay, has devoted himself to researches on these subjects, principally along the coast of South Devon, and he has thrown considerable light on the nature of the rocky floor in certain places, from the evidence of a number of trawled blocks.[1] It is, however, to his observations on Ripple-marks and Wave-action that we wish now to direct attention; and as these subjects appeal also to the mathematician, he has sought aid from Sir G. Stokes and Lord Rayleigh. In 1882 he constructed an experimental tank to test his observations on the production of Ripple-marks, and his conclusions are that they are due to wave-currents, and are independent as a rule of tides and tidal currents. The sand-ripples on beaches are made by alternate currents set up by waves, and those laid bare by the fall of the tide may often be distinguished from the Ripple-marks made at greater depths. The shore Ripple-marks are usually imperfect through loss of their sharp ridges. Wave-currents make ripples with equal sides; continuous currents, or continuous currents disturbing wave-currents, make

[1] Notes on the Submarine Geology of the English Channel off the Coast of South Devon, Trans. Devon. Assoc. 1880–89.

ripples with unequal sides. Ripple-marks on shore are better preserved in pools, where they are more or less protected from continuous currents. The direction of Ripple-marks has, however, no necessary relation to the direction of the wind.

The bottom of Torbay, usually smooth, was found to be strongly rippled by swells following a gale, and the author has discussed at some length the depth to which submarine deposits may be disturbed. Evidence is brought forward, from the occurrence of rolled shells, of disturbance of the bed of the sea at depths up to about 38 fathoms; and even at 40 or 50 fathoms, though the Wave-action may be slight, it is not to be disregarded, at any rate in an area subject to oceanic swells and where there is a tidal current. The evidence obtained from a soda-water bottle dredged up from 40 fathoms, showed that the sea-bottom was subject to alternate periods of rest and disturbance. This bottle was found to contain 55 species of shells, which must have been washed in by wave-currents during heavy storms. *Serpulæ* were growing in the neck of the bottle, and they prevented two of the shells (*Pecten opercularis* and *Fusus gracilis*) from being extracted.[1]

Disturbance in shallower water at depths of six fathoms in Torbay is shown by the occurrence on the shore of two species of *Cardium* (*C. aculeatum* and *C. tuberculatum*). Specimens of the former, which were much rolled, had been derived from the sea-bed beyond the six-fathom line where they are known to flourish. Thus different species of Mollusca come to be grouped sometimes separately, sometimes together in deposits of the same age; while by the changes in the supply of mud or sand species locally become extinct, and may be replaced by another species.[2]

Storm waves help to maintain the general level in the soft materials accumulated on the sea-bottom, and level plateaux of limestone rocks may be formed by rock-boring animals eating down the rock to the level of surrounding accumulations. Marine shoals and sandbanks are commonly the joint production of wave-currents and tidal-currents. The neutral wave-currents keep the component parts in motion, whilst cross-tidal-currents accumulate them.

On the subject of the wearing of sand by marine action, evidence is obtained from the Skerries shoal in Start Bay, where grains are present in all stages of rounding, from the jagged fragment of quartz with its angles just showing wear, to the perfectly smoothed and polished spheroid. Some of the grains of sand exhibit a deposit of secondary quartz, and not only has the original grain been worn, but the crystalline encrustation also. The author believes that on sandbanks where tidal and other currents keep in circulation a small volume of sand, the rounding action of the waves is of importance; for, as he remarks, "The misinterpretation of the origin of the constituent grains of a sandstone may result in utter confusion,

[1] On the Formation of Ripplemark, Proc. Royal Soc. vol. xxxiv. pp. 1–18.

[2] See paper "On the Influence of Wave-currents on the Fauna inhabiting Shallow Seas," Journ. Linn. Soc. (Zoology), vol. xviii. pp. 263–274.

to the extent of substituting arid deserts for marine areas, and lengthy rivers for isolated shoals." [1]

The author points out that the fountain-head of all the misunderstanding about waves among practical men has been Scott Russell's error in assuming that oscillating sea-waves are converted into waves of translation on running through shallow water over a shelving bottom.[2] Mr. Hunt's experiments show that oscillating waves, after traversing a gentle gradient, plunge seawards of the water margin; and he maintains that erosion by plunging waves often extends far seaward of low-tide level. Indeed erosion by the wave-currents of the heaviest oscillating waves extends with diminishing intensity to a depth of at least 40 fathoms.[3]

The observations of the author on the combined action of waves and wind-formed currents in removing and accumulating shingle are of considerable interest and importance, affecting as they do our knowledge of the beach-forms of the present day, and of the agents that produce and modify them. H. B. W.

III.—Memoirs of the Geological Survey of New South Wales. Palæontology, No. 4. The Fossil Fishes of the Hawkesbury Series at Gosford. By Arthur Smith Woodward, F.Z.S., F.G.S. 4to. pp. xiii.+55; with ten Plates and two Geological Sections. (Published by Chas. Potter, Sydney, New South Wales, 1890.)

In consequence of the discovery of some fossil fishes in the Hawkesbury Series at Gosford, New South Wales, the fossil collector of the Geological Survey was set to work in the quarry, with the result, that a fine series of nearly four hundred specimens was obtained; and the present memoir is a detailed description of the species by Mr. A. Smith Woodward, of the British Museum (Natural History), Cromwell Road, S.W.

The geological age of the Hawkesbury Series is not satisfactorily settled, although generally considered to belong to the Trias. It was hoped, therefore, that the fortunate discovery of these fishes would throw much light on the stratigraphical position of a very unfossiliferous set of beds, and this hope has not been disappointed.

Some account of the rocks exposed in the Gosford quarry is given in a preliminary note, by Mr. T. W. Edgeworth David, of the New South Wales Geological Survey, who, judging chiefly from bore-holes in the district, is of opinion that about 2462 feet of strata intervene between the beds containing the fishes and the Coal-measures. This description is accompanied by a geological section of the quarry, and a vertical section of the beds found in the neighbourhood, showing the position of the "Sandy Shale" and

[1] "The Evidence of the Skerries Shoal on the Wearing of Fine Sands by Waves," Trans. Devon. Assoc. 1887.

[2] On the Action of Waves on Sea-Beaches and Sea-Bottoms, Proc. Royal Dublin Soc. vol. iv. pp. 241–290 (1884).

[3] Denudation and Deposition by the Agency of Sea-Waves, experimentally considered. With Preface: "The Story of a Research." Privately printed, 1889.

"Laminated Mudstone" in which the fishes occur. These two sections are given as full-page plates; but by whatever process they may have been reproduced, they compare very unfavourably with the fine series of plates representing the fossils, and are not in keeping with the other parts of the work. It is to be regretted that these rough-looking plates should have been introduced to the detriment of what is otherwise an admirably executed memoir.

The remains of a small Labyrinthodont have been found in this fish bed, and have already been described by Prof. W. J. Stephens, in the Proceedings of the Linnean Society of New South Wales.

Mr. Smith Woodward's description of the Gosford fishes occupies between fifty and sixty pages, and is illustrated by ten excellent lithographic plates by Messrs. Berjeau and Highley. The greater number of these fishes belong to the *Ganoidei*; but among them there is one specimen, referable to the Cestraciont group of Selachians, which is, however, too imperfect to admit of even generic determination; and there are some others, representing the *Dipnoi*, for which a new genus and species, *Gosfordia truncata*, are established. The Ganoids are represented by nine genera, of which one only, *Apatolepis*, is new; but two others, *Myriolepis* and *Cleithrolepis*, were proposed by Sir Philip de M. Grey Egerton in 1864 for specimens from New South Wales, sent over by the Rev. W. B. Clarke. Each of these genera is represented by one or two species, as are also the following six, namely, *Dictyopyge*, *Belonorhynchus*, *Semionotus*, *Pristisomus*, *Pholidophorus*, and *Peltopleurus*. Altogether fourteen new species of Ganoids are described.

After a detailed description of each genus and species the author institutes a comparison with the genera which have been found in the Trias, Rhætic, and Lower Lias of other parts of the world, and in order to show more clearly the position occupied by the Hawkesbury fishes, the important genera from the above formations are arranged in a tabular form. Attention is called to the absence from the Hawkesbury beds of fishes with well-developed vertebral centra, and the conclusion is drawn, that, so far as can be determined by the fishes, the Hawkesbury beds are homotaxial with the Keuper of Europe, or at latest with the Rhætics.

The description of the Gosford fishes has been very carefully and systematically carried out by Mr. Smith Woodward, and the printing and lithographic plates are all that can be desired. Indeed, with the exception of the geological sections alluded to above, the memoir is worthy of the Geological Survey, by which it is issued, and a credit to the editor, and all concerned in its production. E. T. N.

IV.—Annuaire Géologique Universel. Revue de Géologie et Paléontologie. By Dr. L. Carez and H. Douville. Tome v. Année 1888. (Paris, 1890.)

The rapid growth in size in the volumes of the "Revue Geologique Annuaire" has been fully continued in that issued for the year 1888. It consists of 1273 pages as against 922 in the preceding volume, while an increase of 700 entries in the bibliographic index has brought up the number to 3550. The volume is continued on the same plan as its predecessors: it commences with a numbered bibliographic list, in which geology occupies 117 pages, and palæontology 31. The geological part of this is arranged geographically, each section being subdivided stratigraphically. The bulk of the work is occupied by the "Revue," which is treated under three main heads, stratigraphy, topography, and palæontology. Several additions and changes have, as usual, been made in the staff; thus Dr. Trouessart no longer has to review the whole of the Vertebrata and Arthropoda, as Dr. Depéret relieves him of all the Vertebrata but the Mammalia, and MM. Dollfus and Bergeron of the Arthropoda. M. Ch. Brongniart contributes for the first time the article on Insecta. In general geology two new sections have been added, viz. Petrography, by M. U. Le Verrier, and Volcanoes, by Dr. H. Johnston-Lavis. M. Choffat has ceased to review the Jurassic palæontology, but continues in charge of the section on Spain and Portugal. Asia is not this year omitted, as M. de Margerie has contributed a note upon it. The longest sectional review is that on Russia, by Prof. Pavlov, which occupies thirty-three pages; it gives a good idea of the valuable work now being done in that country. The titles of the papers are translated, but the authors' names are transliterated on no definite plan, and this results in many puzzling inconsistencies and anomalies.

The "Annuaire" appears to experience the same difficulty as the "Zoological Record" in getting specialists for all the groups; thus in it some sections have been compiled by men, who, though eminent in their own departments, have no special knowledge of the group they record: in such cases the credit of both works suffers severely.

The English section is admirably done by Dr. Carez: a few misprints are inevitable, as "a visit to *C*hap" (Shap), or the discovery of "pievite" instead of picrite; the author balances a tendency to dock Welsh names, as in "Mynyd Maw," by an unoccasional addition, as in the name of Mr. H. H. Win*d*wood. It might have been better to refer Gastaldi's letter to Sterry Hunt to the Geological Magazine, where it was published verbatim, rather than to the few line abstract in the Brit. Assoc. Reports. No complaint can, however, be made against the "Annuaire" on the ground of not noticing both places of publication of a work, as they carry the system to an almost unnecessary extent: thus all papers published in the Q.J.G.S. are recorded thrice; in the Journal, in the Abstracts of Proceedings, and in the Geological Magazine where the abstracts are reprinted.

In the case of so valuable a guide to current literature the geologist must feel too grateful to be critical. The undertaking is ambitious: it aims at combining the bibliographic completeness of the English Records with the short abstracts of the Neues Jahrbuch. Hence it is not surprising that there are many points to which objection might be made: thus in the important consideration of promptness of publication, it is beaten by the Zoological Record by some five months;[1] it, however, compensates for this by its greater

[1] It is dated 1889 on the title-page, but the preface is correctly given as 1890.

completeness. Thus a record of the Echinoderms which does not include Cotteau's Eocene Échinides (Pal. Franc.), de Loriol's Crinoides Jurassiques, and Échinides crétacés du Portugal, Pomel's Paléontologie de l'Algerie; nor mentions Seune's discoveries in the Pyrenees, White's in Brazil, or de Loriol's additions to the fauna of Angola, cannot be for a moment compared with M. Gauthier's summary of the group. Nevertheless, complete though the work is, there are some few omissions; thus while a paper on the Mauritius Bryozoa, which is solely of zoological interest, is recorded and summarized, the Sarrasins' important work on the Echinothuridæ is not mentioned, though of especial interest to palæontologists. The list of abbreviations, which was quite inadequate in previous volumes, has disappeared entirely from the present, and one is left to guess what is meant by the G.F.F. and the Jahrbuch G.R.A.: the brevity in such cases strikes one as unnecessary in contrast to those in which such words as Rendiconti are printed in full. In many cases there is a lack of uniformity in the abbreviations, and the same work is quoted differently on the same page. Sometimes no reference is given to the place of publication of a paper, as in Sansoni's "Note di mineralogia italiana" (1855). The frequent absence of cross-references in the case of joint authorship is also unfortunate.

In spite of such slips and omissions, it must be admitted that the Annuaire Géologique Universel is the most complete and reliable guide to current geological and palæntological literature. J. W. G.

CORRESPONDENCE

THE CAMBRIAN CONGLOMERATE OF ST. DAVIDS.

Sir,—The statement to which Dr. Hicks objects may be somewhat loosely worded, but if the words used be clearly defined it is not very far from the truth. In speaking of a conglomerate we distinguish "pebbles" and "matrix." When the word "fragment" is used, it is generally supposed to refer to the former; the latter, however, may also contain fragments of smaller size; and with the exception of certain true pebbles from Whitesand Bay and Ramsey Island, all the fragments referred to by Dr. Hicks come under this category. The conglomerate of Ramsey Island is truly "composed" of felsite pebbles, but there is no proof of its age. Elsewhere the conglomerates may *contain* fragments of various rocks, but they are mainly *composed* of quartz pebbles. My statement is a re-echo of the words of Prof. Hughes that "he did not believe that the little particles of felspathic rock in the grit would carry conviction." Indeed in any case it is very extraordinary that though the present beach at Chanter's Seat and elsewhere is strewn with large granite pebbles from the neighbourhood, the older conglomerate is so free from them, and so full of quartz from somewhere else. This fact, which thus stated can scarcely be denied, tends to minimize the interval between the conglomerate and the underlying rocks, and the presence of small fragments of similar rocks which are abundant in Precambrian areas does not do much in the contrary direction.

Sept. 20, 1890. J. F. Blake.

METRICAL *v.* IMPERIAL STANDARDS.

Sir,—It is to be regretted that the valuable space of the pages of the Geol. Mag. are threatened by a discussion of the merits of different systems of weights and measures. The question has been threshed out in the "English Mechanic," photographic and other journals quite recently. As one of those who use metrical measurements in my communications to the three papers mentioned, would you kindly allow me to explain my own reasons, which are probably the same as those of the other culprits. As an Englishman, educated in England, I have the greatest respect for most of her institutions and systems; but I am not *Jingoist* enough (pardon the expression) to extend my patriotic feelings to the irrational system of your so-called Imperial Standards, which cost me many a caning and numerous other miseries during my school-days. When I took up my residence abroad, my mental conception of an inch and a foot was fairly good; but ells, furlongs, miles, gills, pints, gallons, pecks, bushels, grains, scruples, drachms, and many other barbarous units were always very hazy conceptions. My first initiation to metrical measurements was the picture of a decimetre in Roscoe's small chemistry book. I set myself to work for half an hour on two or three occasions, and soon gained a clear mental estimate of all metrical standards which years of patient labour and much practice had failed to give me of Imperial standards. The great point is that the measure of lengths, fluids, solids, with their relations to specific gravity, temperature, coinage, etc., can be calculated in a few seconds by an ordinary person, whilst the relationship of the Imperial standards requires lengthy intricate calculations on paper by a practised mind. So superior do I find the metrical system that I now convert the data of any problem from English to a metrical form, make my calculations, and reconvert the answer to English form.

The objections of the writer of the letter in last month's Geol. Mag. are of the usual invalid kind. In the first place he seems to think one must be a French scholar to understand metrical measurements, whereas if any other than his own language is necessary, it is Greek and Latin, as all the names of the weights and measures are derived from them; but I would ask if the writer of the letter ever attempted to investigate the meanings of furlong, drachm, scruple, carat, and other incomprehensible and useless denominations of our Imperial standard units, whilst a most elementary knowledge is sufficient to explain a decimetre, a milligramme, or a hectolitre. The next error is to refer the use of the metrical system entirely to the French—true it originated in the minds of French philosophers and physicists, but it has long been very extensively adopted by other countries. All said about Englishmen and English journals is out of place, for the metrical system is recognized as legal Standards by Act of the British Imperial Parliament, and it is only our insular conservatism that makes us retain an old, cumbersome, and even dangerous system of Standards not much superior to those used from earliest historic times. If people wish to understand scientific papers where the metrical system is used, it is to be inferred that they are capable of learning that system, which is not more difficult than the multiplication table of 10.

The prognostications of your correspondent I fear are of little value, for I find daily the metrical system is replacing more and more the barbarous standards. I know of some large English engineering works recently opened in Italy where all the English engineers, after a few months' absence from home, adopt the metrical system as far as the inch-calibred machinery will allow, and constantly grumble at the two-foot rule.

Lastly, allow me to state that once it was my practice to put old English equivalents by the side of the metrical measurements, but I dropped the practice because one Editor wrote to me saying that it was a presupposed fact that the readers of his journal understood the metrical system, and it might offend their dignity to be told the English equivalent of 2·5 centimetres, etc. Another Editor wrote that it was superfluous and added to the length of the paper.

Chemists and physicists have universally adopted the metrical system, mathematicians, astronomers, etc., prefer it, and I maintain that geologists—especially those who write for the future in the Geol. Mag.—the least conservative of all scientists, should not be the last to give up an archaic if not an archean system.

Naples, *Oct.* 14*th*, 1890. H. J. Johnston-Lavis.

WIND WAVES AND TIDAL CURRENTS.

Sir,—Allow me to thank Mr. Stirrup for the invaluable information contained in his letter on "Wind Waves and Tidal Currents." It does not, however, affect the position taken up in my letter on "Tidal Action" as to the question of the action or inaction of *Tidal* currents on the floor of the English Channel. The Mediterranean being practically a tideless sea, the currents encountered by M. Fol could not possibly be Tidal, and herein lies the extreme value of the observations.

My investigation of wave-action was undertaken in order to prove the disturbing power of waves on the sea-bottom, and I proved my point up to the hilt, and indeed a little further, as the ascertained amount of disturbance exceeded what the theory of oscillating waves would allow.

In a paper submitted to the British Association in 1886, I pointed to the clean sand and shells in 100 fathoms and more at the mouth of the English Channel as evidence of the presence of wave-currents at a depth far below the reach of the heaviest oscillating waves, and said that "the presence of this deposit of clean sand and shells is at present unaccounted for, for there are no recognized agents competent to disturb and distribute such material below the depth of fifty fathoms:" at the same time I showed how a gale off Queenstown by the general disturbance of the water-level, stirred up seaweed in Torquay Harbour far beyond the radius of the atmospheric disturbance caused by the storm.

In a tidal sea it is impossible to isolate these far-reaching currents from the ordinary tidal- and wave-currents, but now M. Fol in the tideless Mediterranean has done so, and what is of so much importance has clearly distinguished them from such wave- and tidal-currents. As already stated, M. Fol's currents cannot be tidal, but no more can they be attributed to ordinary storm waves, as Mr. Stirrup states that the disturbance is felt nearly as much at 30 metres as at 10 metres. This is also indicated by the character of the motion which is said to make the diver oscillate like a pendulum. An ordinary storm wave would impart more or less of a circular motion.

These wave-currents appear to originate in those swinging waves which, for lack of a better name, I have termed wind-pressure waves. They are moreover quite in their place in the Mediterranean, a sea which is subject to considerable changes of water-level from strong winds.

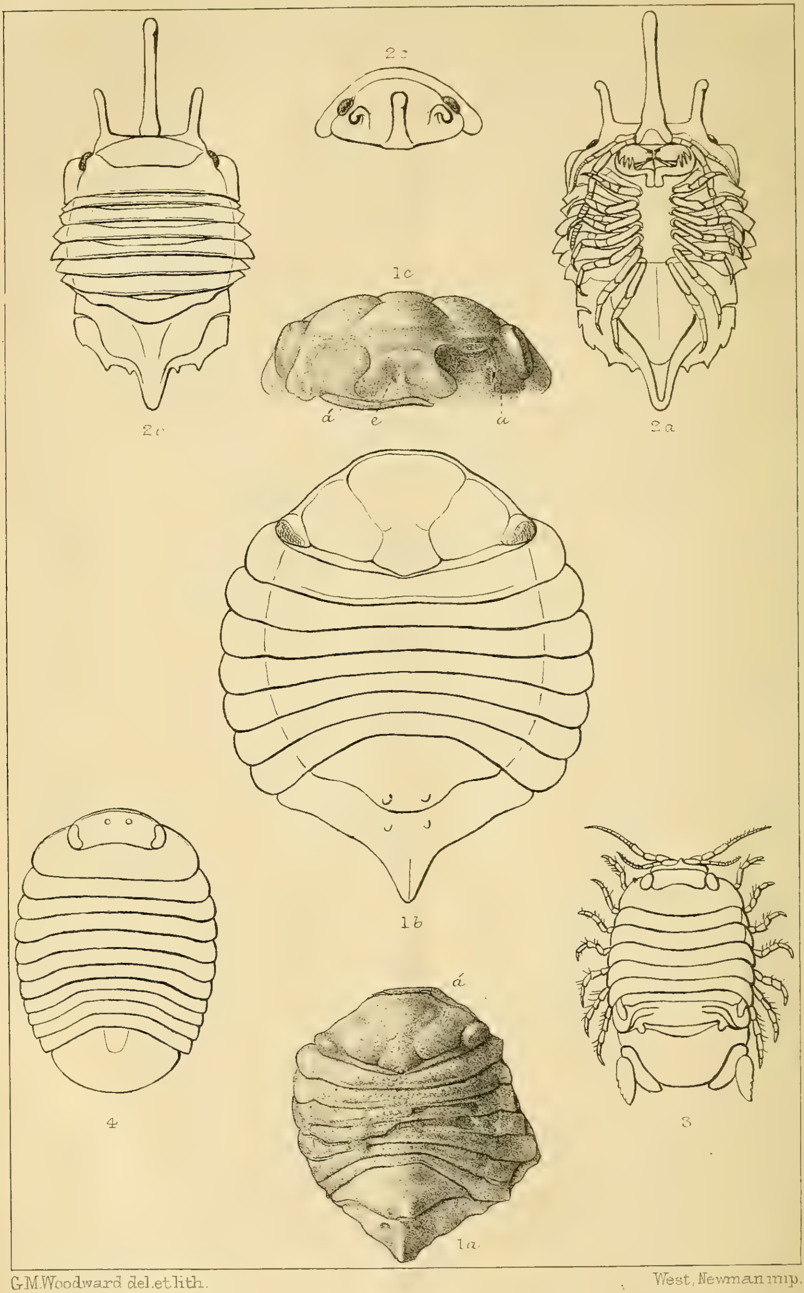
With respect to the English Channel, the tidal currents alone seem powerless to disturb the weakest organism, but occasional storms appear to hurl about gravel as though it were sand, and to give the fauna in general a decidedly bad time of it.

Mr. Stirrup's letter clears up the chief outstanding unexplained point in the problem of the action of waves and currents on the floor of the Channel, and I can only repeat my very sincere thanks for the same. A. R. Hunt.

Southwood, Torquay.

MISCELLANEOUS.

Geological Survey of Ireland and the Royal College of Science.—We regret to learn that Professor Edward Hull, LL.D., F.R.S., severed his connexion upon the 30th September with the Geological Survey of Ireland, of which he has been Director for a period of nearly 21 years. He retires from the service consequently upon the completion of the one-inch Geological Survey of the country. Messrs. G. H. Kinahan, A. B. Wynne, R. J. Cruise, and W. F. Mitchell, have also retired from the service; Mr. Kinahan having served with distinction for a period of 36 years. A small staff has been retained, whose duty it is to keep the maps up to date, to give technical information to persons interested in mineral and similar developments, and to attend to the Survey collection now displayed in the new Science and Art Museum. Mr. J. Nolan (senior geologist) has been appointed chief of the local staff, and there remain with him Messrs. F. W. Egan, J. R. Kilroe, A. McHenry, Dr. J. S. Hyland, and Mr. R. Clarke (Fossil Collector). Professor Hull also resigns his position as Professor of Geology at the Royal College of Science, which he had held conjointly with the Directorship of the Survey. We have much pleasure in stating that Mr. G. A. J. Cole, F.G.S., who for several years has been assistant to Prof. Judd at the Normal School of Science, and has done much original work in Petrology, has been appointed to the vacant Professorship.



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

A new British Isopod
Cyclosphæroma trilobatum, *H. Woodw.*

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VII.

No. XII.—DECEMBER, 1890.

ORIGINAL ARTICLES.

I.—On a New British Isopod (*Cyclosphæroma trilobatum*) from the Great Oolite of Northampton.

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

(PLATE XV.)

MR. THOMAS JESSON, B.A., F.G.S., of Great Houghton House, Northampton, was lately so fortunate as to discover in the Great Oolite of that county, a new and most interesting example of an Isopodous Crustacean, which, by his kindness, I am permitted to figure and record in the Geological Magazine.

The last-described British Isopod was obtained from the Upper Greensand of Cambridge, and made known by Mr. James Carter, F.G.S., in this Magazine.[1] In his paper Mr. Carter gives a careful résumé of our knowledge of the species of this order which have hitherto been found in a fossil state, both British and Foreign, and it will therefore be sufficient, for our present purpose, to refer the reader to that admirable summary.

The specimen, which forms the subject of this article, was found imbedded in compact white crystalline limestone; only the upper surface of the cephalon, the body-segments and the telson being exposed (see Plate XV. Fig. 1*a*). About one-half of the fossil, consisting of the cephalon and the anterior thoracic segments, has the outer crust or shell preserved; the posterior segments, the abdomen and telson are seen as a sharp cast of the animal in the fine calcareous matrix. The margins of the cephalon, the segments and telson have suffered considerably in the process of removal from the parent-rock in which they had been enclosed, thus leaving much to be desiderated before we can obtain a complete and satisfactory knowledge of the fossil.

The epistomial plate, together with traces of the antennules and antennæ, can be made out in front of the cephalon (Pl. XV. Fig. 1*c*); also the basal portion of the left uropodite on the side of the telson.

A careful comparison of Mr. Jesson's specimen with several recent and fossil forms, has satisfied me that it should be placed in the Isopoda, and in the Family Sphæromidæ, of which I here subjoin a brief diagnosis, summarized from Messrs. Spence Bate and J. O. Westwood's excellent work.[2]

[1] See Geol. Mag. 1889, pp. 193–196, Pl. VI. Figs. 1–7.

[2] A History of the British Sessile-eyed Crustacea, by C. Spence Bate and J. O. Westwood, 1868, in 2 vols.; vol. ii. p. 398, etc.

Sphæromidæ.—Body short, broad, and very convex; often contractile into a ball; foot-jaws elongated; in some species the terminal joint is not dilated at the inner apical angle, so as to become palpiform; the head is large and transverse, and in *Sphæroma* the first segment of the thorax is laterally anteriorly produced so as to reach the anterior margin of the cephalon which it embraces on either side (see figure of *Sphæroma serratum*, Fabr. sp., Plate XV. Fig. 3). The mandibles robust and angulated at the extremity, the tips formed into sevaral distinct teeth, below which is a strong molar tubercle. Externally, also, the mandibles are furnished with a palpiform three-jointed appendage. The segments of the thorax do not exhibit, when viewed dorsally, the epimera-like structure of the basal joints of the legs observable in the *Idoteidæ.* The basal segments of the tail (abdomen) are more or less rudimentary, and are in general soldered together, more or less completely, so as to form, apparently, only a single joint, which in many species is furnished with large tubercles or spines.

CYCLOSPHÆROMA, H. Woodw., gen. nov.

General outline nearly circular, almost as broad as it is long. Cephalon rounded and tumid in outline; eyes moderately large, cornea vitreous; thoracic segments seven in number, broader than head-shield or telson, first segment coalesced with the cephalon; segments of abdomen coalesced together, but telson apparently distinct. Appendages ? (imperfectly preserved).

CYCLOSPHÆROMA TRILOBATUM, H. Woodw., gen. et sp. nov. (Pl. XV. Figs. 1*a*, *b*, and *c*.)

Description.—Outline of cephalon elliptical, twice as broad as long; glabella tumid, divided by strongly-marked furrows into three well-defined regions, a central, and two lateral parts; the central portion of the glabella is broadest in front, much constricted near the centre, expanding again into a small pentagonal area behind, where it unites with the first thoracic somite.

The two lateral lobes are ovate-oblong in form, broader in front, and narrower behind, where they abut against the constricted centre of the median lobe. The eyes, which are reniform in outline, and measure 5 mm. in length by $2\frac{1}{2}$ mm. in breadth, occupy the outer posterior angles of the two lateral lobes; the cornea is smooth and glassy, but exhibits distinct facets within (when viewed under a good platyscopic lens). A narrow ridge separated by a double furrow marks the line of division between the cephalon and the first thoracic segment, which in the living *Sphæroma* usually encloses the posterior and lateral margins of the cephalon, with which it is more or less completely united.[1]

[1] In the majority of the Isopoda the "head" segments become fused with the first segment of the thorax, and form a cephalic shield which is freely movable upon the second thoracic segment. In *Serolis* the first and second thoracic segments are closely united, and completely fused dorsally, though the sterna of the two remain distinct; in some species an incomplete transverse suture upon the first epimera seems to mark the line of division between the two segments dorsally; in others the

Viewed from the front (see Pl. XV. Fig. 1*c*) the strongly-marked trilobation of the cephalon is still more clearly seen. The epistomial plate is observable attached to the frontal margin of the glabella; resembling somewhat a short heraldic "label," with two pendant square ends. Traces of the antennules and antennæ occupy the lateral frontal margin of the cephalon, which is deeply excavated on each side for the articulation of their broad basal joints.

The eyes stand out from the antero-lateral angles of the cephalon, the superciliary border being formed by the projecting margin of the lateral lobes, of the head and the inferior border by the encircling lateral margin of the first thoracic segment, which here unites with the front margin of the head-shield (cephalon).

Thoracic segments.—There are seven thoracic segments between the cephalon and the abdomen; each segment is very strongly corrugated, and is narrower in the centre along the median dorsal line, but more expanded towards its free margins or epimera. The first thoracic segment is, without doubt, united to the cephalon, and curves around the lateral margins of the head-shield; the second thoracic segment is also curved somewhat forward at its epimeral margins; the third and fourth are nearly straight; the fifth, sixth, and seventh segments curve rather backwards, being nearly twice as wide at the epimera as on the median dorsal line. The epimeral border of each segment is distinctly marked off and defined by a clear lateral line of division crossing all the segments from near the outer angle of the eye on each side to the anterior outer angle of the abdomen (see Pl. XV. Figs. 1*a*, 1*b*). The posterior margin of the cephalon and that of each thoracic segment, has a narrow raised border, separated by a furrow from the rest of the segment, forming the line of articulation between each segment and the one immediately succeeding it; this union is further strengthened by the enarthroidal articulation of each segment with its neighbouring one near its epimeral border.

Owing to the decorticated condition of the posterior portion of the fossil, any indication of the former divisions of the coalesced segments in the abdomen which may have existed in the crust are wanting; but we have evidence on the cast of two, or more, strong protuberances on this region of the body. The abdomen is two and a half times as broad as it is long, being extremely narrow laterally, somewhat rhomboidal in outline, and must have had spines along its posterior border. Behind the abdomen the body terminates in a "telson," or caudal shield, nearly three times as broad as it is long, but some of the margin of this shield has probably been lost. It had two powerful sub-median spines near the anterior border, and one in the centre near the posterior extremity, which is acutely pointed. The sides are strongly curved and hollowed out for the reception of the flat curved inner lobe of the lateral appendages

epimera of the two thoracic segments are completely united, and show no traces of their original distinctness; these epimera are always largely developed, and completely inclose the cephalic shield on both sides (Frank E. Beddard, Report on the Isopoda collected by H.M.S. "Challenger," during the years 1873–76. Part I. *Serolis*: Zoology, vol. xi. 1884, p. 8).

(uropodites), beneath which the outer lobe is generally concealed. Traces of these, and of the walking appendages of the thorax, can, unfortunately, only be made out in sections in the matrix. The surface of the head-shield and segments, as far as it has been preserved, is curiously carunculated, and the thoracic segments are also ornamented with lines of small tubercles varying in size; save the large spines and prominences which ornament the abdomen and telson, we are unable to speak on account of these portions having been decorticated; but we may fairly conclude that the surface was carunculated like the head-shield. There is a tendency towards a median line of small tubercles down the dorsum, commencing with a rather prominent one in the centre on the posterior border of the cephalon.

Dimensions.—Greatest breadth of cephalon, 25 millimètres; length 13 mm.; greatest breadth of thorax 33 mm.; length of seven thoracic segments on median line 13 mm.; length of abdomen and telson united 15 mm. Total length of fossil 41 mm.

Formation.—Great Oolite. *Locality.*—Northampton.

In the cabinet of Thomas Jesson, Esq., B.A., F.G.S.

Observations.—This is certainly one of the most curious examples of fossil Isopods I have yet seen. Its remarkably-shaped cephalon recalls to mind the genus *Lichas* amongst the Trilobites, but the general form is that of a true Isopod; nevertheless there are several points of great interest in the fossil before us. Besides the trilobation of the head-shield, one cannot fail to notice the prominent marginal eyes inclosed by the first thoracic somite, as is the case in the living genus *Sphæroma*. This segment, in *Sphæroma*; and the first and second thoracic segments united to the head in *Serolis* (see foot-note p. 530), are no doubt homologous with the genal portion (or "free-cheek" of Salter) in the head-shield of the Trilobites, thus affording another link by which to connect the modern Isopoda with the ancient and extinct Trilobita.[1]

I know of only one living form among the *Sphæromidæ* having such strong ornamentation upon the segments, head-shield and telson as is seen in *Cyclosphæroma*; I allude to the curious little form obtained by Dr. Milligan, at Flinder's Island, Bass's Straits, and named by the late Adam White *Ceratocephalus Grayanus*, MS.[2] (see Pl. XV. Figs. 2*a*, *b*, *c*). It has three horn-like prominences on its head-shield, and the telson has the same prolonged pointed termination as in our fossil, with similar protuberances and rugosities on its abdominal shield.

From *Archæoniscus* (Pl. XV. Fig. 4) the only other British Isopod from the Oolitic Series, *Cyclosphæroma* entirely differs, that Purbeck genus being now referred to the *Ægidæ*[3] on account of its free abdominal segments.

[1] See remarks in Monograph on the British Carboniferous Trilobites, by H. Woodward, Pal. Soc. Mon. 1883-84, p. 76.

[2] See Article "Crustacea," Encyclopædia Britannica, 1877, ninth edition, vol. vi. p. 659, fig. 72, A–E, by H. Woodward.

[3] See my paper " On Eocene Crustacea from Gurnet Bay, Isle of Wight," Quart. Journ. Geol. Soc. 1879, vol. xxxv. pl. xv. pp. 342-350, on *Archæoniscus*, p. 349.

Taking a review of the fossil ISOPODA, we may venture to arrange them provisionally as follows:—

I. BOPYRIDÆ.	*Bopyrus*, sp. (parasitic under carapace of *Palæocorystes*), Upper Greensand, Cambridge.
II. ÆGIDÆ.	*Palæga*, 4 species, 2 Cretaceous, 2 Tertiary.
	Ægites, 1 species, Oolite, Solenhofen.
	Archæoniscus, 2 species, Purbeck, Swanage, etc.
III. ARCTURIDÆ.	*Præarcturus*, 1 species, Old Red, Hereford.
	Arthropleura, 1 species, Coal Measures.
IV. SPHÆROMIDÆ.	*Sphæroma*, 4 species, Tertiary, Italy, Calabria, etc.
	Eosphæroma, 2 species, Eocene, Isle of Wight.
	Eosphæroma (=*Palæoniscus*), 2 species, Eocene and Miocene.
	Archæosphæroma, 1 species, Miocene, Bohemia.
	Cyclosphæroma, 1 species, Great Oolite, Northampton.
	Cymodocea, 1 species, Tertiary.
V. ONISCIDÆ.	*Oniscus*, 1 species, Tertiary (in amber).
	Triconiscus, 1 species, Tertiary (in amber).
	Porcellio, 3 species, Tertiary (in amber).
	Armadillo, 1 species, Miocene, Oeningen.

EXPLANATION OF PLATE XV.

FIGS. 1–*a*, *b*, *c*. *Cyclosphæroma trilobatum*, H. Woodw., sp. nov., Great Oolite, Northampton.

FIG. 1*a*. Specimen natural size (*á* position of flagellum of antenna).

FIG. 1*b*. The same as fig. *a*, enlarged 1½ times.

FIG. 1*c*. The same, front view of cephalon, *a* antennule; *á*, part of the antenna; *e* epistomial plate.

FIGS. 2*a*, *b*, *c*. *Ceratocephalus Grayanus* (A. White, MS.) living; Bass's Straits (Mus. Brit. collection), about 4 times natural size.

FIG. 2*a*. dorsal aspect.

FIG. 2*b*. ventral aspect.

FIG. 2*c*. frontal aspect of head.

FIG. 3. *Sphæroma serratum*, Fabr. sp. (length of living specimen about half an inch). English and French coasts, found under stones.

FIG. 4. *Archæoniscus Brodiei*, Milne-Edwards, Purbeck, Swanage, Dorset (magnified 3 times), now referred to the *Ægidæ*.

II.—NOTE ON THE EFFECT OF PRESSURE UPON SERPENTINE IN THE PENNINE ALPS.

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

IN some parts of the Alps serpentine is by no means a rare rock; indeed it is commoner than some geologists (myself included) once supposed, because much that was formerly comprehended under the term 'serpentinous schist' now proves to be true serpentine modified by the effects of pressure.

An Alpine serpentine, when in its most normal condition, so far as I have seen—and my experience is a fairly wide one—varies usually in colour from a dark green to almost black, a red tint being rare. Sometimes it is veined with a lighter green, and the rock that has been affected by pressure is usually of a paler colour, ranging from a fairly rich sage-green to a light greyish-green, the change being no doubt, in part at least, the result of weathering. Small grains of magnetite or chromite may often be detected. Except for this, the structure—apart from the results of mechanical action—is usually compact, though varieties with glittering crystals of bronzite and allied minerals occur. In this case the rock presents a considerable resemblance to the dark serpentine from north of Cadgwith (Lizard), or to those found near Genoa or at Levanto.[1]

One of the largest masses of serpentine in the Alps occurs near the watershed of the Pennine Chain in the neighbourhood of Zermatt. In this region mountain-making has taken place on a grand scale, so that good opportunities are afforded of studying the effects of pressure as an agent of metamorphism. But before considering this, a few words of explanation are necessary for the sake of those who are not familiar with the geology of this region. The snowfields in the neighbourhood of Monte Rosa, upon the north-western side of the watershed, descend towards the Visp in two glaciers—the Gorner and the Findelen—which are separated by a huge buttress or spur. This culminates in a rocky ridge which runs parallel (roughly from east to west) with the former glacier. At its western end is a singular craggy tower, named the Riffelhorn (9616 feet); east of this, the ridge after a depression mounts to the well-known Gorner Grat (10,290 feet), from which it undulates upward along the Hochthäligrat (10,791 feet), and finally culminates in the Stockhorn (11,595 feet).

This huge spur to a great extent consists of serpentine; but on its northern shoulder a considerable area (above the Riffelhaus Inn, 8430 feet) is occupied by a tolerably hard fine-grained green schist, apparently bedded, in which a rather acicular hornblende and sometimes epidote are fairly conspicuous.[2] This mass is completely surrounded by serpentine. The latter rock continues to the summit of the Gorner Grat, where it is succeeded by calc-mica schists, associated with some fissile mica-schists and micaceous gneiss and with a hard white quartz-schist. This group—on the details of which it is, for the present purpose, needless to dwell—is followed, apparently in descending order, by a moderately coarse, rather micaceous, gneiss, of which, so far as I have seen, the remainder of the ridge, up to the peak of the Stockhorn, consists. The annexed section (Fig. 1), which is merely diagrammatic, may serve to render the relation of the rocks, described above, rather more clear.[3]

The serpentine no doubt forms part of the bed of the Gorner glacier, for of it, on the left bank, not only the rocks of the Lychen-

[1] See Geol. Mag. Dec. II. Vol. VI. p. 362; Vol. VII. p. 538. Descriptions of some Alpine serpentines will be found in Mr. Teall's British Petrography, p. 109, *et seq.*

[2] A specimen of one of the harder varieties which I have had sliced consists of a not very characteristic glaucophane (the greater part of the grains being, as has often been described, altered into a dull green hornblende), epidote, garnets (rather small), a little white mica, hematite, etc. It is difficult to offer an opinion as to the origin of these green schists. Some may be modified igneous rocks; others possibly altered tuffs.

[3] According to the Swiss Geological Survey there should be some rauchwacké interstratified near the base of the quartzite, but I omit this rock as I do not hold it to be a member of the crystalline series. The quartz-schist, green-schists, and calc-mica schists belong to the great group of crystalline schists which in the Alps have such a wide distribution and occur at the top of the Crystalline (probably Archæan) series.

bretter, on which rests the Ober Théodule glacier, but also the peak of the Klein Matterhorn (12,752 feet) consist. It appears again on the south side of the Twins and the Breithorn, in the Val d'Ayas, and patches of the same rock, sometimes of considerable size, occur at intervals about the Val d'Aoste and the Graian Alps. West of the above-named mass of serpentine comes a green schist which is indicated on the Swiss map by a colour different from that assigned to the Riffelberg schist; but to my eye there is no marked distinction between the two rocks. Serpentine also occurs in isolated patches among the schists for a distance of many miles in this direction, while on the north-east a kind of tongue protrudes from the mass forming the Riffelberg towards the base of the Findelen glacier, runs in a broad dyke-like mass on its right bank, and then forms another great patch which culminates in the summits of the Allaleinhorn, Rimpfschhorn, and Strahlhorn, whence it extends even as far as the Fee-alp above the Saasthal. The distribution of the serpentine, as mentioned above, is inexplicable on any other supposition than that it is an intrusive rock of igneous origin, though I have not yet seen it either sending off dykes or cutting distinctly across the bedding of the schists. This negative evidence, however, is of little weight, for in the Alps junctions are very often commonly covered up by débris, and I deemed it unnecessary to spend much time in hunting for them, because evidence already obtained in other localities has fully satisfied me as to the history of an ordinary serpentine.

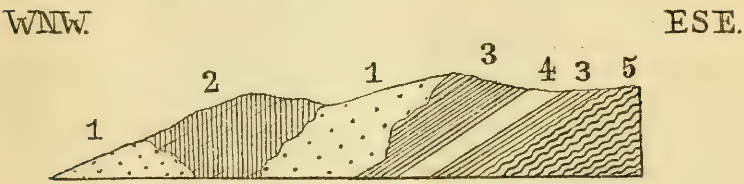


FIG. 1.—Section through Gorner Grat.

(1) Serpentine. (2) Green schist. (3) Calc-mica schist. (4) Quartz-schist. (5) Micaceous gneiss.

The main mass of serpentine, described above, together with the enclosed hornblendic schist, measures rather more than $3\frac{1}{2}$ miles from E. to W. and rather less than $2\frac{1}{4}$ miles from N. to S.; but if we measure from the summit of the Klein Matterhorn to the furthest part of the margin, in a direction rather east of north, the distance is more than five miles. Thus the mass of serpentine at the head of the Vispthal is not less important than that of the Lizard in Cornwall.

Some at least of the schists through which the serpentine appears to have broken must be rocks of sedimentary origin. Whatever may be that of the green-schists and certain of the mica-schists and gneisses in this series, it is impossible to doubt that of the quartz-schist and the calc-mica schist. In the latter micaceous and calcareous bands, these sometimes becoming a crystalline marble, so constantly alternate, that they seem only explicable on the hypothesis of an interstratification of more argillaceous and more calcareous layers. It is also evident that these rocks, after they had assumed a crystalline condition, were modified by a strong pressure, definite in direction. This pressure in many cases appears to have acted at right angles to the planes of the original, or 'stratification-foliation,' and to have superinduced upon it a secondary or 'cleavage-foliation' in the same direction; but sometimes, as for instance may be seen at the very summit of the Gorner Grat, the former structure is folded so as to cross the direction of the latter, which then usually becomes inconspicuous. The bedding in these schists dips roughly to the N.W. or a little W. of this, at an average angle of about 40°, but minor disturbances make a very precise determination almost impossible.

Pyroxenic constituents are generally absent from the serpentine of the Gorner Grat, so far as I have seen, but grains of iron-oxide (magnetite or perhaps chromite) which sometimes attain a fair size are rather common. Thus the rock originally must have been the

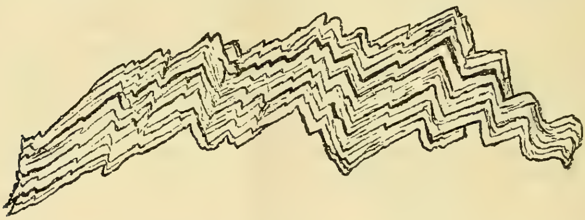


Fig. 2.—Contortions in Slaty Serpentine (natural size).

variety of peridotite called dunite. Occasionally we find specimens of fairly normal serpentine, but the rock commonly is more or less fissile, looking compressed or even crushed. In some places it is converted into a veritable slate, and the mountain is strewn with slabs, which have smooth level surfaces, and exhibit a structure as compact as that of an argillite, so that their true nature might readily be overlooked. But the more normal and only slightly cleaved serpentine can be traced into this slaty kind, which we then see indicates only localities of greater pressure or of less strength in the rock-mass. In some instances (as near the base of the Riffelhorn on its northern side) the serpentine is so fissile that it can be split into films hardly thicker than an ordinary visiting card. I brought away a specimen, perhaps about half a dozen square inches in area (larger could have been easily obtained), which is nowhere thicker than an eighth of an inch, and in not a few parts is actually translucent. Not far from this place I noticed specimens which seemed to indicate that the rock had been twice affected by pressure, for the thin slaty layers were bent into a series of V-like folds, like a row of gables, perhaps half an inch high, and rather less than an inch wide, these bent layers being separable one from another (Fig. 2).[1]

[1] A very fine specimen, on a scale about five times that figured above, was found last summer at the top of the Théodule Pass by Prof. W. Ramsay, F.R.S., and given to our Museum at University College.

I have examined microscopically slices cut from a slab (about 6 or 7 tenths of an inch in thickness) of the above described slaty serpentine, collected from the western slopes of the Gorner Grat. Both were cut at right angles to the flat surface, one along what appeared to be the 'dip' of the cleavage and the other with its 'strike.' The structure in the two slices differs little, but the former is slightly more streaky. The rock [1] consists almost entirely of two minerals. One, forming the matrix, occurs in small translucent flakes or streaky folia of a very pale olive colour; the other, an iron oxide, in rather small black grains (Fig. 3). The former, with crossing Nicols, resembles a streaky felted mass, the folia varying from a rather regular to a lobate or irregular outline. Commonly the flakes lie with their longer axes parallel with the cleavage-planes. Occa-

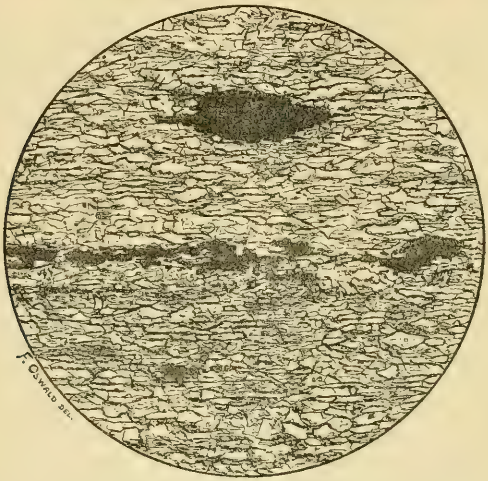


Fig. 3.—Section of Slaty Serpentine from near the summit of Gorner Grat. × 50.

sionally the mineral exhibits a cleavage like a mica, parallel to which extinction occurs, and these also lie in the above direction. Hence the slide as a whole is darkest when placed with the boundary of the cleavage surface parallel with the vibration plane of either Nicol.[2] Then a darkish field is speckled by irregular granules of low tints, white, greyish, or yellowish. It is brightest when the same lines are equally inclined to the vibration planes, a yellowish tint (yellow to orange) dominating. In this position the streaky interweaving of the mineral flakes is more conspicuous. This structure bears some resemblance to tapestry work in wool, where the stitches are irregular in length and more or less in one general direction. Difficult, however, as it is to describe the appearance, it is

[1] The hardness of the rock is between 3 and 3·5, and its S.G. =2·67.

[2] Possibly the mineral may be (in part at least) antigorite. Cf. the description in Teall's British Petrography, p. 113. The larger flakes in my slides show a faint dichroism, but it is imperceptible in the smaller.

familiar to all students of rocks modified by pressure as one which occurs when a mass, composed of grains of fairly uniform size and strength, has been much compressed. The component grains seem to have been flattened out and squeezed together. The other constituent, the iron oxide, can be readily seen by the unaided eye, forming black lines, up to about $\frac{3}{4}$ inch in length, parallel with the rock cleavage, like strokes made with a thick pen. These, on microscopic examination, are found to be composed of grains or granules, more or less aggregated in regular lines, and usually not exhibiting a crystalline form, but being, so far as can be determined, rather lenticular in outline. Generally they are black and perfectly opaque. Sometimes, however, they appear slightly translucent and of a brownish tint, and the adjoining matrix is stained with the same colour, which penetrates for some little distance in a dendritic fashion. There can, I think, be no doubt that these represent grains of magnetite or possibly chromite, which have been crushed up and arranged by pressure in their present form. Once or twice I note lenticular clusters of larger and more definite flakes of the doubly refracting mineral, but can find no distinct trace of a pyroxenic constituent.

At one spot we find in the low bosses which crop out from among the scattered débris two rocks in association, both of which seem to differ from the serpentine. The one is a dark dull-green chloritic rock; the other a talcose rock of a rather pale greyish colour. The hardness of the former is about 2; the latter is still softer, being easily scratched with the finger-nail. The 'chloritic' rock occurs in a series of irregular reef-like masses, and I have no doubt that it is intrusive in the talcose, though both evidently have been modified by pressure and greatly altered from their original condition.[1] The former, when examined under the microscope, is found to consist of a flaky mineral, apparently belonging to the chlorite group, with some flakes and irregular grains of an opaque iron-oxide, and (in the junction-specimens) an occasional grain of a clear rather granular mineral. The chloritic mineral has one well-defined cleavage like a mica; it is moderately dichroic, showing a light dull-green, with vibrations parallel with the cleavage-planes, and a very pale straw colour with vibrations perpendicular to them. The dichroism is more marked in a junction-specimen (where the flakes have a more distinctly parallel arrangement), but this may only be due to a difference in the thickness of the slides. The polarization tints are low, but rather brighter in the latter specimen. Extinction seems generally to take place parallel with the cleavage-planes, but occasionally there is room for doubt on this point, and it appears to be most complete at a very small angle with them. In the junction-specimens the grains of iron-oxide are smaller, and more distinctly linear in arrangement than in the other. In form they resemble hematite. The third mineral has a rather granular structure, is colourless, and gives low polarization tints. I have not seldom seen

[1] I am greatly indebted to Mr. J. Eccles, F.G.S., for verifying the opinion which I had formed, and for much additional information.

a similar mineral in rocks of this character; it has a general resemblance to zoisite, but I cannot venture to identify it.

I am indebted to the kindness of Mr. J. C. Chorley for a bulk analysis of this rock (made in Professor Ramsay's laboratory at University College). It is as follows (No. I.):

	No. I.			No. II.[1]
SiO_2	= 28·92	...	...	28·56
Al_2O_3	= 44·31	...	...	39·54
Fe_2O_3	= 10·86	...	...	0·99
FeO	= 2·93	...	...	2·87
MgO	= 3·98	...	...	15·79
CaO	= trace	...	...	1·73
Na_2O	= 2·98 }	...	...	0·70
K_2O	= 0·67 }			
Moisture	= 5·70	...	...	11·09
	100·35			101·27

Specific gravity of the rock 2·81. This result appeared to be of so much interest that Mr. Chorley kindly verified it by a partial analysis of another sample, and obtained SiO_2=29·88, Al_2O_3=43·56, Fe_2O_3= 10·65. Thus there can be no doubt that the rock, and consequently its chief constituent, has an unusually low percentage of silica and an unusually high one of alumina. It bears macroscopically and microscopically a very close resemblance to a rock described by myself from near Rhoscolyn, Anglesey, and an analysis of that rock made by Mr. F. T. S. Houghton is quoted for comparison (No. II.)[2] The analyses present considerable resemblances: the ratio of the SiO_2 to the Al_2O_3 is but slightly different, there is a larger amount of water in the Anglesey rock, and a smaller amount of the iron oxides. This, however, may be explained. The first is strictly a bulk analysis, not so the second. This rock contains rather conspicuous octahedral crystals of magnetite (probably containing some Cr_2O_3). These were removed because the analysis was made to ascertain of what mineral the matrix was composed, and what was its history. The most marked discrepancy between the two analyses is the amount of MgO, which indicates the presence, in the Rhoscolyn rock, of a mineral richer in magnesia. For purposes of comparison let us denote the alumina in each rock by 100. Then we have approximately.[3]

No. I. (Gorner Grat).					No. II. (Rhoscolyn).
SiO_2	= 65	...	...	...	72
FeO	= 6·5	...	...	...	7
MgO	= 9	...	...	...	39

Hence it seems to follow that the latter rock must either consist of a somewhat different mineral or contain a second mineral rich in magnesia. Still both analyses seem to indicate the presence of a mineral with a low silica percentage, a moderate one of magnesia and iron-protoxide, and a very high one of alumina.

[1] Also traces of Cr_2O_3 and MnO.

[2] Q.J.G.S. vol. xxxvii. (1881) pp. 43-45.

[3] The Fe_2O_3 is not indicated in the comparison, because I believe most of it is present in No. I. as hematite. Thus it will not help us for the present purpose.

What then is this mineral, and what was the rock originally?

I have examined a considerable number of analyses of minerals which have a general resemblance to that dominant in the above described rocks, and are quoted in Dana's "Mineralogy," Heddle's "Chloritic Minerals,"[1] and other works.[2] Now in the case of the Gorner Grat rock the microscope shows us that it is mainly composed of one mineral. Hence the composition of this must be roughly represented by the bulk analysis of the rock (omitting most of the Fe_2O_3). Therefore the mineral cannot be pennite, ripidolite, or chlorite (clinochlore), *i.e.* not one of the chlorites as defined by Professor Heddle. But this analysis nearly approaches those of chloritoid, given by him (I. and II.) except in the presence of alkalies and the much lower percentage of FeO.

	I.	II.	III.[3]	IV.[4]
SiO_2	24·47	25·36	24·90	24·40
Al_2O_3	41·34	41·74	40·99	42·80
Fe_2O_3	·38	3·89	·55 }	19·17
FeO	18·52	13·93	24·28 }	
MnO	·91	·92	—	—
CaO	·30	·90	—	—
MgO	6·80	6·82	3·33	6·17
K_2O	—	—	—	—
Na_2O	—	—	—	—
H_2O	6·98	6·57	7·82	6·90
	99·70	100·41	101·87	99·44

But the hardness of chloritoid is 5·5 to 6, while in this case it is about 2; it has also a higher specific gravity, viz. about 3·5. However, there can be little doubt that it is very nearly related to chloritoid and a member of Tschermak's 'Clintonite' group,[5] which contains this mineral with Ottrelite, Xanthophyllite, etc.

I have not been more successful in endeavouring to ascertain the original nature of the rock. A peridotite is obviously out of the question; the excess of the alumina over the silica is much greater than in any analysis given by Roth. If, however, we suppose that silica has been removed (perhaps with some magnesia and lime), we are perplexed at the percentage of alkalies, which is about that of a normal basalt.

The adjacent schist adds to our difficulty.[6] Its softness and microscopic structure justify us in regarding it as a talc-schist, and the field evidence is in favour of its being only an altered condition of the slaty serpentine. This was my own opinion at the time, and Mr. Eccles, who kindly undertook to re-examine the question, informs me that though the change from the one rock to the other is abrupt, this conclusion appears the more probable.[7] To convert

[1] Trans. Royal Soc. Edin. vol. xxix. (1879) p. 55.

[2] I am indebted to Miss C. A. Raisin for much help in this search.

[3] Analysis of Chloritoid, Tschermak and Sipöcz, Sitz. k.k. Akad. Wiss. 1879.

[4] Analysis of 'Sismondine' from Zermatt, Des Cloiseaux, Bull. Soc. Min. vol. vii. p. 80.

[5] *Loc. cit.*

[6] Curiously enough there is a similar association in Anglesey, Q.J.G.S. vol. xxxvii. p. 44.

[7] After microscopic examination of a specimen collected by Mr. Eccles, I think

a schisty serpentine into a talc-schist, either much SiO_2 must be added or much MgO removed. The condition and structure of the rock is not favourable to the former explanation; it seems more probable that the alteration has been by a 'leaching out' of the magnesia. It is therefore difficult to understand the reason of such different changes in two adjacent rocks, unless it be that an aluminous silicate more readily parts with its silica, and a magnesian silicate with its magnesia, in favour of which there is some evidence. At present, however, I think it safer to restrict myself to calling attention to the facts.

Other specimens of slaty serpentine in my collection exhibit a structure like that described above. For instance in one from the western side of the Col di Vallante (Cottian Alps), which is extremely fissile and of a distinctly green colour, the microscopic structure is yet more minute, the rock more fissile (for it splits up in grinding), but the slice gives higher polarization tints. This also exhibits an occasional bending or 'rucking' of the 'foliation,' which sometimes has produced a 'strain-slip' cleavage. Another specimen, from near Verrex (at the opening of the Val d'Ayas), exhibits a like structure, but in it, I think, a little enstatite has been present. In one less conspicuously fissile, from the junction of glens at the head of the Val Malenco, enstatite and augite are certainly present. Sometimes the latter mineral is crushed to a powder, which has a rather dusty aspect, while the larger granules exhibit the bright tints customary in augite. Here and there a characteristic fragment of that mineral can be found, and we may note that, though the pressure has been very great, it remains augite, and has not been altered into hornblende.[1] This variety of serpentine must exist in some part of the *massif* in the region of the Gorner glacier, for I collected several years since a specimen on one of its moraines, of which, as I had some doubt as to the true nature of the rock, I examined a slide. Here the matrix is less completely crushed than in the specimens described above, and there is a large amount of this granular pulverized augite (at least I identify it with this mineral after comparison with the better preserved examples in the last-named slide). Specimens from other parts of the Alps exhibit both varieties of serpentine, and the effects of less severe pressure; but on these it is needless to enlarge.

It has been suggested that the streaky structure which is rather conspicuous in some of the Lizard serpentines (*e.g.* a variety on Goonhilly Downs and a common type at Porthalla[2]) may be due to pressure.[3] Applying the knowledge obtained in the present investigation, I may venture to express the opinion that these Cornish rocks have not been materially affected by pressure since they

there can be little doubt the rock is an altered serpentine. The dominant mineral has all the characters of talc, but there are several grains of calcite which, by their mode of occurrence, suggest replacement (? of augite).

[1] There are however not a few minute grains of a honey-brown, somewhat dichroic, mineral which *may* be a variety of hornblende.

[2] Q.J.G.S. vol. xxxix. pp. 21–23.

[3] Geol. Mag. Dec. III. Vol. IV. p. 137.

became serpentines. It might, however, still be affirmed that they were crushed as peridotites and were afterwards converted into serpentines. I possess only one specimen of a peridotite modified by pressure, but this lends no support to that hypothesis, and the structure of the accidental constituents in the Cornish serpentines does not appear to suggest it, so that I think we must seek for some other explanation.

It results then from this investigation that in a large number of cases the direct effect of 'dynamometamorphism' on a serpentine is not to produce any marked mineral change, but only to reduce the magnitude of the constituents and to impress upon them a linear arrangement, more or less marked. Under ordinary circumstances it does not appear to generate one of the soft unctuous talcose schists, though such a change sometimes occurs. This, however, must be accompanied, as stated above, by considerable chemical alteration, because in olivine or serpentine (and in the rocks mainly composed of these minerals) the silica and the magnesia are nearly equal in amount; while in talc the former is about double that of the latter. There is also a lower proportion of H_2O. Perhaps, in such cases, some local cause may have given to the water a more distinctly solvent action.

III.—A Revision of the Group of *Nautilus elegans*, J. Sowerby.

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OWING to the defective character of Sowerby's description and figure of *Nautilus elegans*, the latter has been variously interpreted, specimens belonging to other species having been frequently referred to it. In the present paper we shall show what is the true *N. elegans*, tracing the history of the type-specimen, which we have been fortunate enough to identify in the collection of the British Museum. This done, we shall proceed to describe three other species, viz. *N. elegantoides*, d'Orbigny, *N. Atlas*, Whiteaves, and *N. pseudoelegans*, d'Orbigny, all evidently allied to *N. elegans*, and forming with it a group of species which may be appropriately called the "Group of *Nautilus elegans*."

The identity of *Nautilus elegans*, J. Sowerby, has hitherto been completely mistaken, owing to the uncertainty existing as to the true character of Sowerby's fossil, the type of which had not been recognized.

The following is Sowerby's description of this species: "Gibbose, umbilicate, with numerous linear, reflexed radiating sulci. About two-thirds as thick as wide; the septa are rather numerous, gently waved; the aperture is obtusely sagittate, with the posterior angles truncated; umbilicus small, perhaps closed." Respecting the type-specimen Sowerby states, "This fine specimen was found in the chalk marle, at Ringmer in Sussex, in 1814, by Mr. Mantell."

It is undoubtedly Sowerby's type-specimen which Mantell figures in his Fossils of the South Downs, tab. xx. fig. 1, and which he states "was discovered in a marl bank at Middleham, in the winter of 1814."

The apparent discrepancy between these two localities is explained by Mantell's remark on page 100 of the work just quoted, viz. that "a low bank at Middleham in the parish of Ringmer, near the seat of the Rev. J. Constable, contains *Hamites, Turrilites, Nautilites, Ammonites* and *Inocerami*."

There is in the British Museum (Natural History) a specimen from Dr. Mantell's collection, bearing an old label in faded ink, to the following effect:—"*Nautilus elegans*, Min. Con. pl. 116, ... Chalk Marl . . . . . Estate of Rev. J. Constable, Ringmer."

On comparing this fossil with the figures of *Nautilus elegans* given by Sowerby [1] and Mantell,[2] no doubt can be entertained as to its identity with them. The figures have been restored to some extent, but not in such a way as to disguise altogether the characters of the fossil. The foreshortening of the figure, a practice often indulged in by Sowerby, added not a little to the difficulty of realizing the form of the shell.[3] Moreover, Sowerby's figure is reversed.

An exact drawing of the fossil is here given (Fig. 1, p. 548), which is intended to supply the deficiencies of Sowerby's figure, and render the species more easily recognizable.

Having identified Sowerby's type-specimen, it will now be useful to notice, on the one hand, those species which, being in reality *N. elegans*, have had some other name erroneously applied to them, and, on the other hand, those species which have been wrongly named *N. elegans*. Sharpe has fallen into both these errors. His *Nautilus elegans* [4] is not that of Sowerby, but a much wider and thicker shell, with closed umbilicus and the siphuncle above the centre. The specimen which he figured as *Nautilus pseudoelegans* [5] is now in the Museum of the Geological Society of London, and an examination of the fossil leaves no doubt whatever that it is identical with Sowerby's type of *N. elegans*, as Sharpe's figure, which is fairly accurate, had indeed led one to conclude.

The source of this confusion is easily explained. Sharpe has relied upon d'Orbigny's descriptions of the Chalk Nautili, in which the definition of *N. elegans* (Pal. Franç. Terr. Crét. 1840, t. 1, p. 87) departs so widely from Sowerby's, as to show that d'Orbigny's fossil [6] was distinct from the latter.

Dr. Paul Fischer, of the Museum of Natural History, Paris, with very great kindness, sent to one of us the original specimen figured by

[1] Min. Conch. vol. ii. 1816, p. 33, pl. cxvi.

[2] Fossils of the South Downs; or Illustrations of the Geology of Sussex, p. 112, pl. xx. f. 1 (not pl. xxi. ff. 1, 4, 8).

[3] This has been a stumbling-block to many. F. B. Meek (United States Geol. Surv. Terr. vol. ix. 1876, p. 500, footnote) says:—"his [Sowerby's] single figure being an oblique view does not show the form of the aperture."

[4] "Description of the Fossil Remains of Mollusca found in the Chalk of England" (Mon. Pal. Soc.), 1853, pt. i. Cephalopoda, p. 12, pl. iii. f. 3; pl. iv. f. 1.

[5] *Ibid.* p. 13, pl. iv. figs. 2*a*, 2*b*.

[6] D'Orbigny's *N. elegans* will now be known as *Nautilus Atlas*, a name proposed for it by J. F. Whiteaves (*see* post, p. 550).

d'Orbigny under the name *Nautilus elegans* (Pal. Franç. Terr. Crét. 1840, tom. i. p. 87, pl. xix.), thus enabling us to observe the difference between the latter, as interpreted by d'Orbigny, and the true *Nautilus elegans* of Sowerby (see Fig. 1).

Along with the figured type of *Nautilus elegans*, d'Orbigny, kindly lent by Dr. Fischer, is one which, though sent as an example of that species, differs materially from d'Orbigny's shell, its form being much more compressed, and the sutures closer together and more curved than those of the latter. These characters unite it with the *N. elegans* of Sowerby, and it is interesting to find this species occurring in France. Dr. Fischer states that the French specimen is from the Cénomanien (Lower Chalk).

Pictet and Campiche,[1] writing in 1859, give no figures of *N. elegans*, but they recapitulate its characters (p. 117), saying, however, that its umbilicus is "très-grand," whereas Sowerby describes it as "small, perhaps closed." On the same page of their work these authors, referring to Mantell's figure of *N. elegans*, say that it probably represents a different species; but it is in truth a figure of the same specimen as that which formed the subject of Sowerby's figure in the "Mineral Conchology."

In 1866 Stoliczka,[2] referring to the Indian Cretaceous specimens, identified by Blanford as *Nautilus elegans*, states that they "agree well with the European [form], and the external position of the siphuncle can be often noticed on fragments in our collection." The "external position of the siphuncle" and the general form of the shell would associate the Indian species with d'Orbigny's, were it not that the ribbing in the latter appears to be finer, and the French form is, perhaps, on the whole, somewhat thicker than the Indian. As we have been able to examine only the single, badly-preserved young example of the latter which is in the British Museum, we cannot say whether d'Orbigny's fossil is or is not identical with Blanford's.

In 1876 Dr. Clemens Schlüter,[3] in describing a new species of *Nautilus*, which he designates *N. Sharpei*, remarks upon the distinctness of the *Nautilus elegans* of d'Orbigny and Sharpe from the *N. elegans* of Sowerby.

Meek, in association with Hayden,[4] described in 1862 an American fossil as *N. elegans*, var. *Nebrascensis*.

Not satisfied with Sowerby's imperfect description and foreshortened figure, Meek[5] adopted with some hesitation Sharpe's interpretation of *Nautilus elegans*, and in 1876, after reconsideration, he gave up the varietal name on account of the resemblance of his form to the *N. elegans* of Sharpe, which he naturally supposed to be identical with Sowerby's species. He evidently, however, had his

[1] Description des Foss. du Terr. Crét. Environs de Sainte-Croix (Pal. Suisse), sér. ii. pt. i. 1859, pp. 117, 136.

[2] Mem. Geol. Survey India—Palæont. Indica—I. Cretaceous Cephalopoda of Southern India, 1866, p. 209.

[3] Cephalopoden der oberen deutschen Kreide, Abth. ii., Palæontographica, 1876, Band xxiv. (51) 171, Taf. xlvi. ff. 5–7.

[4] Proceed. Acad. Nat. Sci. Philadelphia, 1862, vol. xiv. p. 25.

[5] United States Geol. Surv. Terr. 1876, vol. ix. pp. 499–501.

doubts about the correctness of Sharpe's identification of the species in question; for, after describing the American form, he remarks that he believes the latter "will be found to agree so closely with Sowerby's species, that there may be no necessity for separating it, even as a variety—that is, if Mr. Sharpe's illustrations can be relied upon." He continues, "From Sowerby's application of the words 'indistinctly sagittate,' however, to the aperture, it would seem that his type-specimen must be much more compressed than ours, which, as already stated, agrees well with Sharpe's figures in form. As Sharpe ought to have been well acquainted, however, with Sowerby's species, I infer that the latter's original type may have been *accidentally* compressed." It will be seen from this quotation that Meek was not quite satisfied in his mind as to the identity of Sharpe's species with Sowerby's. He comments upon the retention by Pictet,[1] and also by Blanford,[2] of the name *Nautilus elegans* for d'Orbigny's type; and remarks that "if *N. elegans*, d'Orbigny, is specifically distinct from the previously published *N. elegans*, Sowerby (which seems very probable), of course d'Orbigny's shell will have to receive some other name, as two species of the same genus cannot retain the same name." The required name has been supplied by Mr. Whiteaves,[3] who proposes to call d'Orbigny's fossil *Nautilus Atlas*.

Judging by Meek's careful description and admirable figures of the American form, it appears to be distinct from *N. elegans*, Sowerby, and also from d'Orbigny's and Sharpe's *N. elegans*, which have been renamed *N. Atlas*. Although Meek's form has undoubted affinities with the last-named species, it differs in having a much wider shell, an open though small umbilicus, at least in the adult, and the siphuncle somewhat nearer the centre. On the whole, it is more like the Indian form already mentioned than the French form, *N. Atlas*.

Regarding Meek's form—*N. elegans*, var. *Nebrascensis*—Mr. Whiteaves[4] expresses the following opinion:—that "the description of the Nebraska fossil . . . . accords much better with that of *N. Atlas* (nobis) than with Sowerby's diagnosis of his *N. elegans*. The globose shape, together with the position of the siphuncle in the American shell, are in favour of this view, but it is possible that the varietal name, proposed by Mr. Meek, may have to be raised to specific rank, as the sculpture of the so-called 'variety *Nebrascensis*' is said to consist of ribs which are 'five times as broad as the grooves between,' and in this respect it differs from *N. Atlas*, as well as from allied species."

It is due to Mr. Whiteaves to observe that he arrived at the conclusion, from a careful study of the descriptions of the species, that the *Nautilus elegans* of d'Orbigny and of Sharpe was distinct from

[1] Descr. des Foss. du Terr. Crét. des Environs de Sainte-Croix (Pal. Suisse), sér. ii. pt. i. 1859, p. 117.

[2] Mem. Geol. Surv. India—Palæont. Indica—I. Cretaceous Cephalopoda of Southern India, 1861, p. 29; Ibid. 1866, p. 209.

[3] Geological Survey of Canada—Mesozoic Fossils, 1876, vol. i. pt. i. p. 17.

[4] *Ibid.* p. 18.

the *N. elegans* of Sowerby, before he was aware that Pictet[1] had already pointed this out.

With Sowerby's *Nautilus elegans* has often been confounded the *Nautilus pseudoelegans* of d'Orbigny. The true characters of the latter species we have been able to observe from two specimens, which Dr. Paul Fischer, of the Museum of Natural History, Paris, very kindly sent to one of us from the d'Orbigny collection. One of these is figured in Fig. 3. The species is readily distinguished from *Nautilus elegans* by its much thicker and more robust form, closer septa, the position of its siphuncle, and the coarser character of its ornaments. It is also met with at a lower horizon, both in England and France, than Sowerby's species. From *N. Atlas* it differs in the broader periphery, open umbilicus, closer septa, and position of its siphuncle, which is near the inner margin of the septa, instead of the outer, as in *N. Atlas.* The ornamentation of the test is also much finer in the latter than it is in the present species. The *N. pseudoelegans* referred to by English geologists is probably that of Sharpe, which has been shown above to be Sowerby's *N. elegans.*

According to MM. Pictet and Campiche[2] *N. pseudoelegans* presents some variations in the Sainte-Croix specimens, those authors distinguishing four distinct types, of which they give figures (plates xiv. and xiv. *bis* of the work cited above). The first of these types, which is from Yonne, is remarkable for the smoothness of the test in the young shell; the second, from Sainte-Croix, differs very little from the first, being only slightly more compressed. The third type scarcely differs at all from the two preceding ones. In the fourth some slight variations in the position of the siphuncle are noticed. In the Indian examples of the present species figured by Blanford the ribs are much coarser than they are in the English specimens, and indeed on comparing the specimens from the d'Orbigny collection with Blanford and Stoliczka's[3] figures and descriptions there is reason to doubt the identity of the Indian with the European forms, although the two forms are nearly related. Blanford's description of the species is as follows:—"Shell inflated, evenly rounded, ornamented with numerous sulcations generally visible on the cast. Ventral area broad and rounded. Umbilicus impressed and very small in the cast; the perforation not exceeding $\frac{1}{20}$ of the diameter of the shell. The sulcations rather variable in width, narrow on most specimens, forming a very obtuse angulation on the median ventral line, whence the sulci curve forward towards the umbilicus (generally becoming obsolete on the sides of the cast), and forming a very slight flexure towards the umbilicus. Aperture orbicular; septa numerous, about 22 to the whorl, the margins [sutures] slightly flexuous at the sides, straight or slightly convex

[1] Descr. des Foss. du Terr. Crét. des Environs de Sainte-Croix (Pal. Suisse), sér. ii. pt. i. 1859, p. 117.

[2] *Ibid.* pp. 123–128.

[3] Mem. Geol. Surv. of India—Palæont. Indica— I. Cretaceous Cephalopoda of Southern India, p. 33, pl. xvii. f. 3, pl. xviii. ff. 3, 3*a*, 3*b*, pl. xix. pl. xx. ff. 1, 1*a*.

in the ventral region." The siphuncle was subsequently to this description ascertained to be "rather approaching to the inner margin of the septa."[1]

The principal feature in which the Indian differs from the European form lies in the more narrowly rounded periphery, and altogether less robust habit of the shell, next in the smaller umbilicus, and, lastly, in the character of the ribbing, which seems to have been coarser in the Indian than it is in the French form. Blanford's fig. 2 (*loc. cit.* pl. xix.) certainly gives one the impression of being that of a much narrower shell than d'Orbigny's type. As all the specimens in the Indian Survey Collection are stated to be casts, it is not surprising that their characters (especially the ornaments of the test) should not have been very satisfactorily made out.

The four species comprised in the group of *Nautilus elegans*, J. Sowerby, will now be described, beginning with the typical form. We have confined ourselves to those few references in which the species can be verified by means of adequate descriptions and figures.

NAUTILUS ELEGANS, J. Sowerby.

1816. *Nautilus elegans*, J. Sowerby, Min. Conch. vol. ii. p. 33, pl. cxvi.
1822. *Nautilus elegans*, Mantell, The Fossils of the South Downs; or, Illustrations of the Geology of Sussex, p. 112, pl. xx. fig. 1 (not pl. xxi. figs. 1, 4, 8).
1849. *Nautilus elegans*, Quenstedt, Die Cephalopoden, p. 57, Tab. ii. fig. 7 (reduced from Sowerby's figure in the Min. Conch. pl. cxvi.).
1853. *Nautilus pseudoelegans*, Sharpe, Description of the Fossil Remains of Mollusca found in the Chalk of England (Mon. Pal. Soc.), pt. 1, Cephalopoda, p. 13, pl. iv. figs. 2*a*, 2*b* (not pl. iii. fig. 3, nor pl. iv. fig. 1).
? 1872. *Nautilus elegans*, Geinitz, Palæontographica, Band xx. pt. ii. "Das Elbthalgebirge in Sachsen," pt. ii. p. 181, Taf. xxxii. fig. 6.
[*Not* 1840. *Nautilus elegans*, d'Orbigny, Paléontologie Française, Terrains Crét. tome i. p. 87, pl. xix.—1850. *Nautilus elegans*, d'Orbigny, Prodr. de Paléont. Stratigr. tome ii. p. 145.—1853. *Nautilus elegans*, Sharpe, Description of the Fossil Remains of Mollusca found in the Chalk of England, pt. i. Ceph., Mon. Pal. Soc. p. 12, pl. iii. fig. 3; pl. iv. fig. 1.—1861. *Nautilus elegans*, Blanford, Mem. Geol. Surv. India—Palæontologia Indica—I. Cretaceous Cephalopoda of Southern India, p. 29, pl. viii. fig. 4; pl. xvi. figs. 1–4.—1866, *Nautilus elegans*, Stoliczka, Mem. Geol. Surv. India—Palæont. Indica, I. Cretaceous Cephalopoda of Southern India, p. 209.—1876. *Nautilus elegans*, Meek, Rep. United States Geol. Surv. Terr. vol. ix. p. 499, pl. viii. figs. 2*a–c*.]

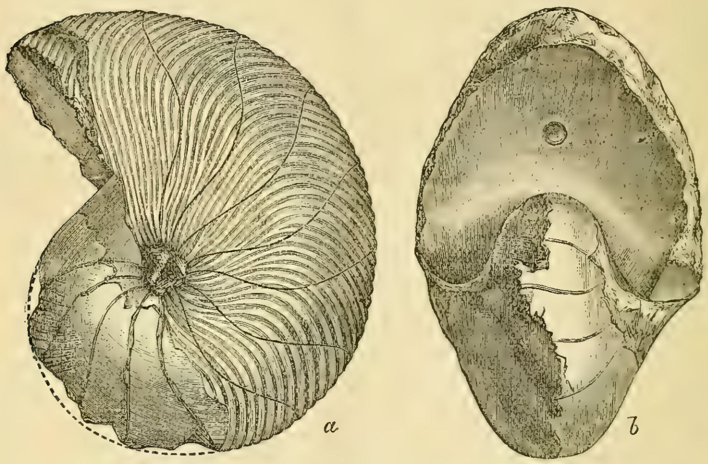
Specific Characters.—"Gibbose, umbilicate, with numerous linear, reflexed, radiating sulci. About two-thirds as thick as wide; the septa are rather numerous, gently waved; the aperture is obtusely sagittate, with the posterior angles truncated; umbilicus small, perhaps closed." (*J. Sowerby.*)

A more exact description of the species may be given as follows: "Shell inflated, somewhat flattened upon the sides, rather narrowly rounded upon the periphery; whorls deeply embracing. Umbilicus small. Septa moderately distant from each other, being $1\frac{1}{3}$ inches apart upon the periphery in the type-specimen, where the height of the whorl, measured from the umbilicus, is about $4\frac{1}{4}$ inches. The

[1] Stoliczka, Mem. Geol. Surv. of India—Palæont. Indica—I. Cretaceous Cephalapoda of Southern India, p. 210, pl. xciii. f. 3.

sutures are bent backwards in a broad sinus on the sides of the shell, and are nearly straight on the periphery. Siphuncle about its own diameter below the centre. Ornaments of the test (type-specimen) consisting of regular, transverse, prominent ribs (flattened in casts), separated by interspaces about half the width of the ribs, occasionally bifurcating; about seven of the ribs are contained in the space of an inch; they are curved sigmoidally on the sides of the shell, and form a deep sinus upon the periphery.

FIG. 1.



Nautilus elegans.—*a*, lateral view of a cast, showing the sutures and ribbing; the umbilicus is partly filled with the matrix; *b*, front view, showing the position of the siphuncle. Drawn from Sowerby's type-specimen (No. 5671) contained in the British Museum. A little more than one-third natural size.

Remarks.—English specimens of this species are usually in a compressed and distorted condition; but there is a specimen in the British Museum Collection (No. C. 37), which is quite uncompressed and shows the characters of the species admirably—sutures, siphuncle, etc. The largest specimen we have seen measures about one foot in its greatest diameter, and in its greatest breadth about $6\frac{1}{2}$ inches.

Affinities and Differences.—*Nautilus elegans* is allied to *N. pseudo-elegans*, d'Orb., but differs from it in having a much more compressed form and finer ribbing. *N. Atlas*, Whiteaves, is a more inflated shell, and has the siphuncle near the periphery. *N. elegantoides*, d'Orb., differs from *N. elegans* in the more quadrate section of its whorls, in having the siphuncle nearer the inner (dorsal) margin and the ribs straighter on the sides of the shell and more frequently subdivided.

Horizon and Locality.—Lower Chalk. Folkestone, Kent; Ringmer and Lewes, Sussex; Ventnor, Isle of Wight; Cliffe Anstey, Wiltshire.

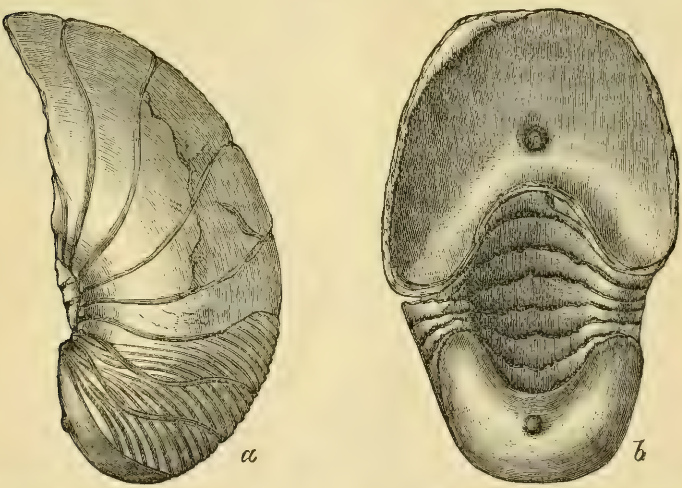
NAUTILUS ELEGANTOIDES, d'Orbigny.

1840. *Nautilus elegantoides*, d'Orbigny, Paléontologie Française, Terrains Crétacés, tome i. p. 89.

Sp. Char.—This species is briefly described by d'Orbigny (*loc. cit.*) in the following paragraph :—" Il parait donc constant, d'après les observations des géologues et d'après mes observations personelles, que le *Nautilus elegans* est spécial aux couches des craies tufau ; car, tous les fragmens que j'ai recueillis dans le grès vert de la Normandie (Vaches noires), me portent à croire qu'il y existe encore une autre espèce voisine de l'*elegans*, mais bien plus étroite, et à siphon plus médian, que j'ai nominée *Nautilus elegantoides*, mais je ne la possède pas assez complète pour la caractériser nettement."

Remarks.—As no mention is made of this species by d'Orbigny in his 'Prodrome' or elsewhere, it may be assumed that he never succeeded in obtaining such material as would have enabled him to describe the species completely. There is, however, a specimen in the British Museum (No. 37001) which possesses all the characters essential for the diagnosis of the species, which may thus be described :—Shell somewhat inflated, sides and periphery rather flattened, thus giving a squarish form to the whorls in section ; widest part of the whorls in the umbilical region. Umbilicus open, of moderate size. Septa moderately distant; sutures considerably

FIG. 2.



Nautilus elegantoides.—*a*, lateral view of a very imperfect specimen, showing the form of the sutures ; *b*, front view, showing the position of the siphuncle. Drawn from a specimen in the British Museum. One-third natural size.

curved backwards on the sides of the shell, and forming a conspicuous sinus on the periphery. Siphuncle considerably below the centre of the septa. Ornaments (seen only on the cast) consisting of strong, prominent, transverse ribs, which often separate into bundles of from two to four after leaving the umbilicus, so that in the umbilical region they are much wider and coarser than in any other part of the shell. The interspaces dividing the ribs do not exceed one-half the width of the latter. The ribs are only slightly curved on the sides of the shell, but they form a conspicuous sinus on the periphery. The body-chamber is unknown.

Affinities and Differences.—This species most nearly resembles *Nautilus elegans*, J. Sow., but differs both in its general form, in the position of the siphuncle, and in the character of its ornaments.

Horizon and Locality.—Grès Vert (Upper Greensand). Honfleur (Calvados), France.

NAUTILUS ATLAS, Whiteaves.

1840. *Nautilus elegans*, d'Orbigny, Paléontologie Française (Terrains Crétacés), tome i. p. 87, pl. xix. (*Not* of J. Sowerby.)

1850. *Nautilus elegans*, d'Orbigny, Prodrome de Paléontologie Stratigraphique, tome ii. p. 145. (*Not* of J. Sowerby.)

1853. *Nautilus elegans*, Sharpe, Description of the Fossil Remains of the Mollusca found in the Chalk of England (Mon. Pal. Soc.), pt. i. Cephalopoda, p. 12, pl. iii. fig. 3; pl. iv. fig. 1. (*Not* of J. Sowerby.)

1876. *Nautilus Atlas*, Whiteaves, Geol. Surv. of Canada, Mesozoic Fossils, vol. i. pt. i. p. 17.

Specific Characters.—Shell inflated, broadly rounded on the periphery, which makes a continuous arch with the sides and imparts a semilunate outline to the whorls when seen in section. The greatest breadth of the whorls is therefore a little above the umbilical region. Umbilicus closed. The septa are rather distant, being (type specimen) $1\frac{1}{3}$ inches apart where the height of the whorl, measured from the umbilicus to the median line of the periphery, is $3\frac{1}{2}$ inches. Siphuncle situated considerably above the centre of the septa. Test ornamented with rather strong, prominent, rounded ribs, separated from each other by interspaces equal to about half the diameter of the ribs. The latter make a broad forwardly-directed curve on the sides of the shell, and a broad and shallow sinus on the periphery. Owing to the lateral compression undergone by some specimens, this sinus appears very deep in them, but in uncompressed specimens, of which there are a few in the British Museum collection, the sinus is always shallow. The ribs leave their mark upon the cast in the form of faint plications.

Remarks.—The above description is drawn up mainly from d'Orbigny's figured type; but there is in the British Museum a fairly good example (No. C. 1027) from the same horizon and locality (Craie chloritée, Rouen) as d'Orbigny's specimen. The same Museum contains also some fairly well preserved English specimens.

Affinities and Differences.—The inflated form of the present species, the closed umbilicus, and the position of the siphuncle (nearer the peripheral border) are characters which distinguish this species from *N. elegans*, J. Sow.

Horizon and Locality.—Lower Chalk. Dover and Burham, Kent; Lewes and Newhaven, Sussex; Cliffe Anstey and Calne, Wiltshire; Ventnor, Isle of Wight; Rouen (Calvados), France.

NAUTILUS PSEUDOELEGANS, d'Orbigny.

1840. *Nautilus pseudoelegans*. d'Orbigny, Paléontologie Française (Terrains Crétacés), tome i. p. 70, pl. viii., pl. ix.

1853. *Nautilus pseudoelegans*, Sharpe, Description of the Fossil Remains of Mollusca found in the Chalk of England (Mon. Pal. Soc.), pt. i. Cephalopoda, p. 13, pl. iv. figs. 2*a*, 2*b*.

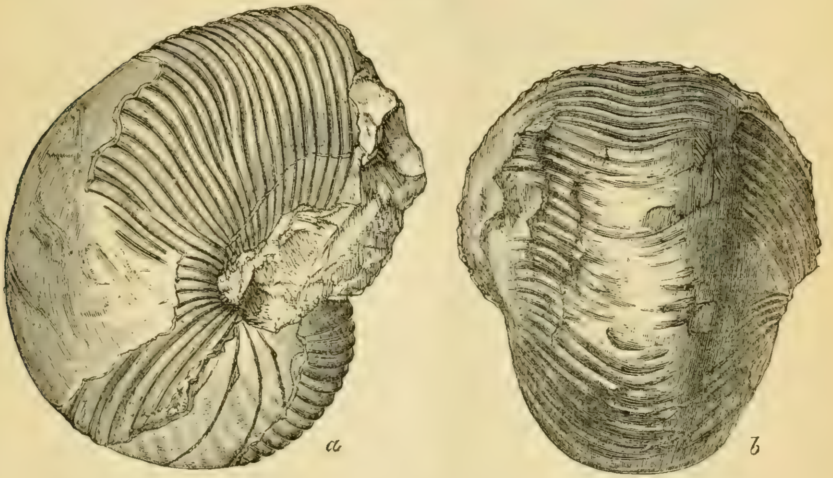
1858. *Nautilus pseudoelegans*, Pillet, Description Géologique des Environs d'Aix en Savoie, p. 33, pl. vi. fig. 3.

1859. *Nautilus pseudoelegans*, Pictet et Campiche, Description des Fossiles des Environs de Sainte-Croix (Paléontologie Suisse, sér. ii. pt. i. livr. vii.), p. 123, pl. xiv. and xiv. *bis*.

? 1861. *Nautilus pseudoelegans*, Blanford, Mem. Geol. Surv. of India—Palæont. Indica—I. Cretaceous Cephalopoda of Southern India, p. 33, pl. xvii. fig. 3; pl. xviii. figs. 3, 3*a*, 3*b*; pl. xix.; pl xx. figs. 1, 1*a*.

? 1866. *Nautilus pseudoelegans*, Stoliczka, *ibid.* p. 210, pl. xciii. fig. 3.

FIG. 3.



Nautilus pseudoelegans.—*a*, lateral view, showing three of the septa, and the cast of the body-chamber, partly covered by the test; *b*, peripheral view, showing the curvature of the septa in the median line. Drawn from a specimen in the d'Orbigny Collection in the Museum of Natural History, Paris. About one-third natural size.[1]

Specific Characters.—Shell much inflated, very broad, with somewhat flattened sides and a very broadly rounded periphery, slightly flattened in the adult shell. Greatest width of the whorls about midway between the umbilicus and the median line of the periphery. Umbilicus small but distinct. Aperture very wide, semi-lunate, with rounded lateral margins. Septa approximate, very slightly sinuous on the sides of the shell, and forming an inconspicuous sinus on the periphery. Siphuncle situated below the centre of the septa. Test in the young shell very slightly striated transversely, but in the adult covered with very strong, regular, prominent, separate ribs or plications, which form a sigmoid curve on the sides of the shell, and

[1] A cast of this specimen is now in the British Museum.

rather a deep sinus on the periphery. The ribs bifurcate, and even trifurcate, in some places on the sides of the shell; the interspaces dividing them are about one-half the width of the ribs themselves. The ribs mark the cast with very conspicuous plications; the former become flattened by weathering, but, where well preserved, they are seen to be distinctly rounded.

Remarks.—In a letter just received by one of us, Dr. Paul Fischer makes the following interesting observations on the present species, and we gather from his remarks that there is no hope of determining with certainty the specimen selected by d'Orbigny as his type. Dr. Fischer states: "The type of *Nautilus pseudoelegans* is difficult to recognize. According to the dimensions given in the original diagnosis (diameter 240 millimètres, thickness 160 mm. Paléont. Franç p. 60) our specimens, No. 4834 D, which were sent to you, are typical.[1] Moreover, they come from the neighbourhood of Vandeuvre (Département de l'Aube), where the species was found.

"But the drawing given by d'Orbigny is faulty; first, its dimensions do not agree with the description; then the drawing being reduced to one-third the natural size, the specimen which it represents should have been at least 360 mm. in diameter; besides, the ornaments are wanting in the drawing on a great part of the last whorl. . . . .

"Consider then the figure by d'Orbigny as only approximate. D'Orbigny has restored a great many of his plates, for which, in my opinion, he is very much to blame. . . . .

"In the d'Orbigny collection no specimen is specially marked as the type. But d'Archaic (Hist. du progrès de la géologie, vol. iv. p. 295) quotes *N. pseudoelegans*, and he has given to the Museum a specimen marked *type*. This specimen is small (greatest diameter 150 mm.), and agrees neither with the figure nor with the dimensions given in d'Orbigny's original description.

"Perhaps the true type was contained in the collection of the geologist, Clément Mullet, who showed d'Orbigny over the locality where *N. pseudoelegans* abounds?"

The majority of the British examples of this species which we have seen are very much crushed. There is, however, in the British Museum collection a large natural cast (No. C 1368) which in all probability belongs to this species. It is from the Lower Greensand and measures 1 foot 2 inches in its greatest diameter and about 8 inches in width. The septa are rather distant from each other, being about two inches apart on the sides of the shell; the sutures are slightly flexuous upon the sides and also upon the periphery. The test is not preserved, but the robust form of this specimen and its general appearance ally it to *N. pseudoelegans*.

Affinities and Differences.—These will be found detailed on p. 546.

Horizon and Locality.—Lower Greensand. Maidstone and Sandgate, Kent.

[1] Two specimens were sent, both numbered 4834 D; the larger one is represented in Fig. 3.

IV.—On Some Fossils from Central Africa.

By Professor T. Rupert Jones, F.R.S., F.G.S., etc.

In Professor Henry Drummond's "Tropical Africa," 8vo. London, 1888, pp. 183–199 are occupied with an interesting "Geological Sketch" of the country between the Zambesi River (about 18° S. Lat.) and the Tanganyika plateau (about 3° S. Lat.), his own observations having been made along a route from Kilimane on the coast, to the Shiré, and up that river, by Lake Shirwa and Lake Nyassa, to Karonga (or Karonga's village) on the north west shore near the end of the lake; and thence through the Uchungu district, for about 70 miles, in a part of the Tanganyika plateau. This region, like most of the country bordering the lake, is composed of "granite and gneiss." There are igneous rocks on the north-eastern shore at the lake's head; and a stretch of sedimentary strata for about twenty miles south of Karonga on the shore, and further south inland away from the lake (as indicated on the map in Prof. Drummond's book). These strata are referred to as "red and grey sandstones, fine conglomerate, limestone, shale, and coal," and are shown on the map as the same as some west of the Lake Tanganyika,—some about six degrees to the East, towards Zanzibar,—and some on and below the Zambesi, including Livingstone's coal-beds at Teté on that river.[1] Indeed these beds are correlated (at p. 185) with the series in Cape Colony and Natal known as the Karoo Formation,—at all events as having "a somewhat similar relation" to the gneissic plateau.

Coal.—At page 187, Prof. Drummond refers to a locality where coal was found some years ago by Mr. Cecil Rhodes, examined subsequently by Mr. James Stewart, and revisited by himself—namely, "on the western shore of Lake Nyassa, about 10° South Latitude." He does not report so favourably of this coal-seam as Mr. J. Stewart did in the "Proceed. R. Geograph. Soc." new series, vol. iii. 1881, p. 264. The latter observer noticed that in the valley of the Rikuru, running northward across 10° 45′ S. Lat., there is a great change from "the granite and quartz, which prevail throughout the whole country from the Murchison Cataracts on the Shiré River to Lake Tanganyika," to argillaceous rocks and shales, hard and soft, with sandstone, dipping 1 in $2\frac{1}{2}$ west and by north. Reaching the mouth of the Rikuru on Lake Nyassa, in south latitude 10° 45″ 15′, and going northward along the coast, after three miles he came to "the stream in which is the coal discovered by Mr. Rhodes. The coal lies in a clay bank tilted up at an angle of 45°, dip west. It is laid bare over only some 30 feet, and is about seven feet thick. It hardly looks as if it were in its original bed. The coal is broken and thrown about, as if it had been brought down by a landslip, and traces of clay are found in the interstices. Yet the bed is compact and full of good coal. I traced it along the hillside for some 200 yards, and found it cropping out on the surface here and there. It

[1] It is mentioned at p. 186 that the black rock on the western border of the Shiré valley, at about 17° S. lat. thought by Livingstone to be coal, probably is a "very dark diorite," which is present among the igneous rocks there.

is 500 feet above the lake-level, and about a mile and a half from the shore. I lit a good fire with it, which burned up strongly. The coal softened and threw out gas bubbles, but gave no gas jets. It caked slightly, but not so as to impede its burning. It is found in the main gorge of the Chisindiré valley," about six miles S. by E. of Mount Waller.

Visiting Mount Waller (*op. cit.* p. 265), Mr. J. Stewart found it to consist of horizontal argillaceous and sandy beds, hard and soft, for 900 feet upwards; then three bands of coarse grit, standing out along the mountain-side, form a ledge, at 1200 feet, 300 or 400 yards wide; a precipitous mass of soft shales succeeds up to 2630 feet above the lake; and then a cliff of hard compact argillaceous rock, of a dull straw-colour, in beds 10 or more feet thick, with intervening crumbling shales, reaches 3100 feet above the lake (4700 feet above sea-level).

Respecting the coal mentioned above, a footnote at p. 264 adds:—"Having submitted a specimen of this coal to Mr. Carruthers, F.R.S., Keeper of the Botanical Department, British Museum, this eminent authority has sent me the following note of the results of his examination of it:—'The coal has the appearance of a good specimen of English coal. The lines of stratification are indicated by films of . . . . mother-coal. The general form of the minute tissues are preserved in the mother-coal,—I have observed fragments of scalariform vessels; and in sections of the coal prepared for the microscope I have found the macrospores of Lycopodiaceous plants, which I cannot distinguish from similar bodies in the coal of England. After combustion only 1·8 per cent. of ash remains. I have no doubt that the specimen from Lake Nyassa is of the same age as the coal of England.'"

The hand-specimen of coal examined by Mr. Carruthers is labelled—"Coal from Mt. Waller, Lake Nyassa. Livingstonia, 22 May, 1880, Jas. Stewart." Presumably the locality is not exactly Mount Waller, but in its neighbourhood as defined above. It has an irregular oblong shape, about 6 inches long, 3½ wide, and 3 thick; and consists of close-set parallel laminæ, some of dull, compact, cannel-like coal, and some of bright, crackled glance-coal, all irregular in their relative thicknesses, and seldom more than a quarter of an inch thick. Mother-coal (dull, fibrous, black wood-carbon) lies on an outer (uppermost) layer of the glance-coal, and probably is present at intervals in the mass.

Slices taken from the same block and prepared for the microscope were sent to Mr. R. Kidston, F.G.S., of Stirling, and he favoured me with the following letter (dated January 27, 1890):—

"I have examined carefully the two slides of Coal from near Lake Nyassa. . . . The slides sent would be classed under the descriptive term of 'Spore-Coal,' in so far as spores (macrospores) enter largely into the composition of the Nyassa specimen.

"Spore-coal generally occurs as bands of greater or less thickness in the structureless bituminous matter. Not having seen the block of coal from which the slides were taken, I cannot, of course, say whether all the specimen had a similar composition, or whether the slides represent portions of a spore-band.

"The spores are much smaller than the macrospores usually entering into the composition of British 'Spore-coal,' but seem to be composed of an identical substance. The spores are of a reddish-amber colour. In certain parts of the slides bands of similarly coloured material occur. Although all structure is effaced in these bands, I have no doubt that they are derived from similar macrospores. The more numerous the spores in coal, the better is the quality, on account of their highly inflammable resinous quality."

Alluding to the above-mentioned coal near the mouth of the Rikuru (see p. 553), Prof. Drummond states at page 188 of his "Tropical Africa,"—"I examined this section pretty carefully, and fear I must differ slightly from Mr. Stewart in his geological and economical view of the formation. The 7-foot seam described by Stewart is certainly a deception, the seam being really composed of a series of thin beds of alternately carbonaceous and argillaceous matter, few of the layers of coal being more than an inch in thickness. With some of the most carefully selected specimens I lit a fire, but with disappointing results. Combustion was slow and without flame. Although there were what can be called *films* of really good coal here and there, the mineral, on the whole, seemed of inferior quality, and useless as a steam-coal. From the general indications of the locality I should judge that the coal existed only in limited quantity; while the position of the bed at the top of a rocky gorge renders the deposit all but inaccessible. On the whole, therefore, the Lake-Nyassa coal, so far as opened up at present, can scarcely be regarded as having any great economical importance, although the geological interest of such a mineral in this region is considerable. Sections of the coal have already been prepared for the microscope, and Mr. Carruthers, of the British Museum, has identified the macrospores of Lycopodiaceous plants, which are identical with similar organisms found in the coal-fields of England."

The specimen of coal from the neighbourhood of Mount Waller, described above, lent to Mr. Carruthers, and kindly submitted for examination, certainly seems to agree better with Mr. Stewart's description, above quoted (p. 554), than with Prof. Drummond's foregoing note on the character of his specimens. The variation of a seam, both as to structure and composition, within a limited area, may possibly account for the difference.

Fossils.—At about 60 miles N. by W. from the locality where the above-mentioned coal was obtained, Prof. Drummond discovered, at Maramura (as by label), not far from Karonga, on Lake Nyassa (and about 20 miles along the "Stevenson Road" to Lake Tanganyika), some interesting fossils, as mentioned at pages 191–195 of his book—"About a dozen miles from the north-western lake shore on the route to Tanganyika, after following the Rukuru River through a defile of granite rocks, I came, to my great surprise, upon a well-marked series of stratified beds. At a bend in the river a fine section is exposed. They lie thrown against the granitic rocks, which here show signs of disturbance; and consist of thin beds of very fine light-grey sandstone, and blue and grey shales, with an occasional band of grey limestone. By camping on the spot for some days, and working patiently, I was rewarded with the discovery of fossils. . . . The shale naturally yields the most results, one layer especially being one mass of small *Lamellibranchiata*. . . . Vegetable remains are feebly represented by a few reeds and grasses. Fish-scales abound; but I was only able, and that after much labour, to unearth two or three imperfect specimens of the fishes themselves. These have been put into the accomplished hands of Dr. Traquair, of Edinburgh, who has been kind enough to furnish the following account of them" (in letter, dated 23rd April, 1888).

Dr. Traquair refers to and describes (pp. 193–195) six specimens of fossil Fish-remains: No. 1. *Acrolepis* (?) *Drummondi*, sp. nov. No. 2. In a piece of cream-coloured limestone, besides numerous minute scales and a fragment of a small jaw and teeth, some larger scales and bones, provisionally referred to *Acrolepis* (?) *Africanus*, sp. nov. Nos. 3 and 4. Small pieces of similar limestone with minute scales, like those mentioned above. No. 5. Grey micaceous shale with scales of another, but indeterminable, species of Fish. No. 6. The clavicle of a small Fish, in shale similar to the foregoing. All these are remains of Palæoniscid Fish.

We may remark that Fish of this kind and order are such as are found also in the great Karoo Formation of the Orange-Free-State and Cape Colony, incidentally referred to above.

Prof. Drummond writes at p. 195, with reference to the fossiliferous strata which he so fortunately met with, that they "seem to occupy a comparatively limited area, and have a very high dip in a south-easterly direction. At the spot where my observations were taken they did not extend over more than half a mile of country, but it is possible that the formation may persist for a long distance in other directions. Indeed, I traced it for some miles in the direction in which, some fifty or sixty miles off, lay the coal already described, and to which it may possibly be related."

The fossil shells collected by Professor Henry Drummond, F.R.S.E., F.G.S., etc., at Maramura, near the north-west shore of Lake Nyassa, in Central Africa, occur in a piece of greenish-grey shale, somewhat micaceous, numerous casts of small Bivalves, on two bed-planes, forming its upper and lower surfaces. On one face the casts are convex; on the other, only hollow impressions. Similar casts, in the same relative position, are inclosed in the shale; and small fragments of Fish-remains are sparsely scattered throughout. The convex casts are brown, and on them here and there dark-brown films partially represent the original shells. The concave impressions have brown-black irony stains.

The shells are oval-oblong, or suboblong, rounded at the ends unequally; the posterior being somewhat truncate, and the anterior obliquely-truncate, with an ogee curve below the umbo. Hinge-line long and straight; ventral margin slightly curved. Various degrees of imbedment affect the visible shape; some individuals showing only a triangular outline. The surface is moderately convex, and bears rather strong concentric lines of growth.

These fossils have a general resemblance to the *Iridinæ* described and figured by D. Sharpe in the "Transact. Geol. Soc." ser. 2, vol. vii. pp. 225, 226, pl. xxviii. figs. 2–4. These were from the Karoo Formation at Graaff-Reynet in the Cape Colony. The concentric markings in the specimens from Maramura are stronger than those in fig. 4; and the shell is more oblong, more nearly vertical at the anterior end, rather fuller on the ventral, and straighter on the dorsal margin. It is not so truncate anteriorly as fig. 2, and not so square behind, nor is its umbo so near the middle of the back. The dimensions are—length 20 mm. (hinge-line 15 mm.); height 10 mm. We have nothing to add as to its generic relationship; and, as it differs specifically from *Iridina? rhomboidalis* and *I.? ovata*, it may be distinguished as *Iridina? oblonga*, sp. nov.

A portion of the piece of fossiliferous shale, with *Iridina* (?) *oblonga*, sp. nov., from Maramura, north-west of Lake Nyassa, Central Africa. Natural size.

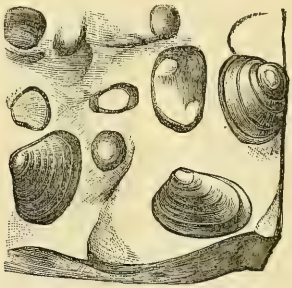
The *Iridina* may be regarded as of Mesozoic age, as well as the associated reed-like and grass-like plant-remains, and the palæoniscid Fishes; for all these are represented in the same series of strata with the Mesozoic *Dicynodon* and other Reptiles, *Cyrenæ*, plant-remains, and coal of apparently the same period. The wide extension northward of the Karoo Formation, as probably represented by these Maramura beds, is an important addition to our knowledge of African geology.

Prof. Dr. W. C. Williamson, F.R.S., informs me that he has not found in South-African coals "decided evidence of *spores*, especially *macrospores*, such as we get in so many of the British splint-coals. The nearest approaches have been in the Cyphergat, the bottom and middle Molteno, the Wynberg on the Sand River, and Slater's coal.

In each of these a vertical section of the coal exhibits numerous very thin horizontal yellow lines, not unlike what we see in our English spore-bearing coals; but I have no proof that these lines were due to spores."

Mr. E. T. Newton, F.G.S., some years ago examined microscopically a piece of compact coal from Andreas's (or Andries's) Nek, a spur of the Stormberg, sent by the late Dr. G. Grey, see Quart. Journ. Geol. Soc. vol. xxvii. 1871, p. 51; and he says that "the coal is bright and bituminous, with partings of dull material, apparently 'mother-coal,' but there are no traces of *spores*. The section shows the bituminous part as dark-brown laminæ, similar to the bright parts of Wallsend coal; but there are no spores to be distinguished. The 'mother-coal' remains black and opake in section." [1]

Corrigenda.—At page 410 (September Number of Geol. Mag.) for the woodcut and the description substitute the following:—



A portion of one of the blocks from the Kat River, Eastern Province, South Africa, showing four of the small shells (*Cyrena ? neglecta*) and parts and sections of others. Natural size.

At p. 410, line 7 from bottom, for "*Cyrenæ*" (?) read "*Cyrenæ ?*"

V.—The Effects Produced by Earth-movements on pre-Cambrian and Lower Palæozoic Rocks in some Sections in Wales and Shropshire.

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

(Read at British Association, 1890.)

In this paper I purpose giving a few examples to show the powerful influences which have been exerted by Earth-movements in producing changes in the rocks, and in obliterating the evidences of succession in some of the disturbed areas in Wales and Shropshire. For a long time past it has been well known that certain changes such as cleavage, etc., have been induced in the rocks in Wales and elsewhere by pressure, but only of late years has the magnitude of the results due to Earth-movements been

[1] See also the "Mining Journal," Decemb. 4, 1886, for a paper on the Coals of South Africa.

fully understood. The difficulties experienced by geologists who visit these areas for the first time are mainly due to their being unable or unwilling to recognize the extraordinary effects produced by these Earth-movements, and especially to the complications resulting from faults and thrusts. In these areas it commonly happens that portions of the pre-Cambrian rocks are forced in among the Lower Palæozoic rocks so as to appear either to be parts of the series or to be intruded into it. In other places it occasionally happens that not only are lower beds of the same series made to appear to overlie much newer beds, but the pre-Cambrian rocks are, in some cases, thrust over those of Palæozoic age.

The rocks in the neighbourhood of St. David's, Pembrokeshire, have suffered in a remarkable degree from the effects of Earth-movements, and some geologists who have visited that area have been led to make not only serious errors, but some very extraordinary statements, from being unable to recognize this fact.

A section across the St. David's promontory shows that after the Cambrian and Ordovician rocks had been gradually deposited over an irregular surface of pre-Cambrian rocks, great Earth-movements took place which caused the Cambrian and Ordovician rocks to be bent into great folds. These folds were broken during these movements by numerous faults, some of great magnitude. Subsequent denudation has revealed the presence, within these folds, of the pre-Cambrian rocks on which the newer rocks were deposited, and has enabled us to recognize the enormous dislocations of the strata which have taken place, and the changes induced in the rocks during the movements. Although there are evidences of several folds of Lower Palæozoic rocks, containing cores of pre-Cambrian rocks, in North Pembrokeshire, it will be sufficient to refer to the one which occurs in the promontory of St. David's, taking a line across it from St. David's Head on the N.W. to St. Bride's Bay to the S.E. of the city of St. David's. At, and near, St. David's Head, great masses of intrusive basic rocks traverse the Arenig rocks, in a direction nearly parallel with the lines of bedding, being probably portions of sheets in the form of Laccolites. These, along with the slates, have suffered from the pressure, proving that the folding took place after they were intruded into the slates. The Arenig rocks are separated from the Tremadoc rocks along this line by a thrust-fault which has diminished the thickness of the strata by about 1500 feet. Other faults in the arch-limb of this fold have repeatedly caused newer rocks to be thrust forward to hide the underlying series, and near the axis, beds at least 5000 feet apart in the succession are by that means brought into contact. On the S.E. side of the axis the Cambrian beds have been inverted and faulted so as to cause the older beds to overlie the newer, evidently by movements from N.W. to S.E.

In the pre-Cambrian core itself the Pebidian rocks are not only sheared to an enormous extent, but are also made, on the S. side, by reversed faults to appear to lie under parts of the granitoid rocks (Dimetian). This result causes the Dimetian to look in places as if intruded into the Pebidian beds, whilst in reality it is everywhere bounded by faults, some of them of pre-Cambrian, others of post-Cambrian age. Similar effects to those witnessed at St. David's and in other areas in N. Pembrokeshire, may be seen in sections in Carnarvonshire, especially in the area between the Menai Straits and the Snowdon district. In the part of this area lying between Carnarvon and Llyn Padarn, not only are the Cambrian rocks, by reversed faults, made to appear to underlie pre-Cambrian rocks, but even Arenig beds are faulted so as to dip under both. The movements in this area have taken place mainly from S.E. to N.W. and the rocks of the Snowdonian range have been driven westward by repeated thrusts.

In a section in Shropshire, extending from the Longmynd across Caer Caradoc, Lower Palæozoic rocks are faulted on the W. side so as to appear to underlie the pre-Cambrian rocks of Caer Caradoc, whilst on the E. as the result of thrust-movements, the older beds have been hidden by much newer ones. Here the post-Ordovician movements were mainly, as in Carnarvonshire, from S.E. to N.W.

The changes which have been produced in the rocks themselves are also very marked. The granitoid rocks give evidence of having been greatly crushed by the Earth-movements in pre-Cambrian times, and in the lines of fracture secondary minerals have been freely deposited. That these secondary minerals date back to pre-Cambrian times is shown by the fact that the pebbles of these granitoid rocks in the Cambrian conglomerates contain all the evidences of the early crush with secondary minerals in the crush-lines, in addition to those of subsequent fractures and deformation by pressure after they had been entombed in the conglomerates. In some places the granitoid rocks and diorites have suffered so much from pressure that they have put on a distinctly gneissic aspect. Some of the felstones in pre-Cambrian times were crushed so that they were formed into felsitic schists, and fragments of these schists occur frequently in the Cambrian conglomerates. Various dykes in the pre-Cambrian rocks exhibit indications of having suffered greatly from mechanical pressure in pre-Cambrian times, the diabase dykes in the Dimetian being frequently cleaved so as to look almost like slates. Fragments of these and of many other cleaved and altered rocks are often found in the Cambrian conglomerates.

In the Cambrian and Ordovician rocks the evidences of pressure during subsequent Earth-movements are also abundant, and secondary minerals have been freely developed along planes of cleavage and in lines of fracture. The effects on some of these rocks near thrust-planes are well exemplified by the remarkably distorted condition of some of the fossils. In one case near St. David's an *Orthis*, which in its normal condition was about seven lines in width, was so distorted that it measured over 27 lines, and others were still further drawn out so as to be almost unrecognizable.

VI.—The Date of the High Continental Elevation of America.

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

THE proofs of a much greater elevation of the American continent at no very distant geological date, which have been communicated to the Geol. Mag. by Prof. J. W. Spencer[1] and Mr. W. Upham,[2] are very interesting, and Mr. Upham's suggestion that this great elevation occurred in Pliocene and early Pleistocene time is a taking one. He thinks the culmination of the uplift coincided with the Glacial period, and was to a large extent the cause of that period; if he is right, we are forced to infer that there has been a post-Glacial submergence to the extent of over 3000 feet over the whole region, including the Gulf of Mexico. There is, however, a difficulty in this supposition, to which I beg to call Mr. Upham's attention.

The raised coral-reefs of the West Indies indicate a recent upheaval of the whole Caribbean region. In the west of Cuba these reefs occur up to 1200 feet, on the testimony of Prof. Agassiz,[3] who found recent species of corals in them at that height between Havana and Matanzas, and up to 1800 feet near Baracoa on the testimony of Mr. W. O. Crosby.[4] In Guadaloupe and Barbadoes they occur up to heights of 1300 and 1100 feet respectively, while the lowest terraces consist of soft and unconsolidated coral rock containing recent species of shells in a fresh-looking condition. It is clear in fact that there has been a regional uplift of this area to the extent of at least 1300 and probably 2000 feet in Pleistocene times, and that there has been no subsequent subsidence. Moreover, this area of elevation certainly included Yucatan, which lies on the south side of the Gulf of Mexico.

Now if the whole North American continent, including a part now covered by the Gulf of Mexico, has subsided 3000 feet since the Glacial period, it is strange to find proofs of contemporaneous elevation over the whole Caribbean region with a distance of only 400 to 500 miles between them. That there should have been in such recent times a differential movement sinking the northern part of the Gulf of Mexico through 3000 feet and raising its southern shores through more than 1300 feet, is rather a large demand on our belief.

It is Mr. Upham who must face this difficulty, for Prof. Spencer was careful not to fix the exact date of the high continental period, and only speaks of its culmination "in the later Tertiary, before the Pleistocene period." Now it happens that the Caribbean region affords evidence of a great depression preceding the elevation above mentioned. Thus in Jamaica the "White Limestone" is in part of deep-water origin, it covers a very large area in the island and is regarded as being of Pliocene age. Again, the Oceanic deposits of Barbadoes seem to indicate a subsidence of at least 6,000 feet, for they rest on shallow-water deposits, and consist of consolidated oozes comparable to those which are now found at depths of

[1] May Number, p. 208. [2] November Number, p. 492.
[3] See Three Cruises of the Blake, vol. i. p. 71.
[4] Proc. Boston Nat. Hist. Soc. vol. xxii. p. 126.

1000 to 2000 fathoms. The deposits appear to be of Pliocene or early Pleistocene age, and are covered by the raised coral-reefs.

Here, then, we seem to have a series of changes corresponding to those indicated by Prof. Spencer (*loc. cit.* p. 209), and it is surely more probable that the movements in the two contiguous areas were contemporaneous than that so great a submergence in the one should correspond with a period of high elevation in the other.

There is however an objection which Mr. Upham might urge against this view, and which I may as well anticipate: it is contained in his remark that the depression "evidently took place in a late geologic period, else the channels would have become filled with sediments." But have they not been partially filled up? Dr. Spencer remarks, "The soundings show that to within comparatively short distances of their mouths, the depths of the valleys below the surface of the seas sometimes did not exceed from 1200 to 1800 feet, but that beyond there was a great increase in depth within the last few leagues." He assumes that the present slope of the floors of the valleys does not materially differ from that they possessed as terrestrial surfaces, but surely the peculiar conformation he describes may be due to the partial infilling of the valleys with sediment, for a certain distance from the shore.

Again it is possible that the surface current of the modern river creates a submarine return current, and that the action of the latter causes less sediment to be laid down over the valley area than over the plateaux on each side. Dr. Buchanan has investigated a deep depression at the mouth of the Congo, and has gone so far as to suggest that the cañon-like trough is entirely due to the action of such a current, the mud brought down by the river being spread out over tracts to the right and left, while the tract over which the main current runs is kept clear by a strong reverse current of sea-water. Thus he supposes the bottom of the trough to represent the original outline of the continental shelf and the shore slopes on each side to have been built up by deposition of material.

Without going so far as this, it does seem possible that, if a deep-cut valley was carried below the sea more rapidly than deposition could fill it up,—a submarine current might be set up which would prevent the accumulation of more than a certain amount of sediment within it. Consequently the valley might remain as an open trough for a long period of time, and its existence could not be regarded as a proof of the recent submergence of the area.

VII.—Note on Dynamic-Metamorphism.

By the Rev. Dr. Irving, B.A., F.G.S.

I HAVE elsewhere pointed out[1] the importance of the two factors —(1) the lateral force which produces the metataxic work (*quâ* cleavage), (2) the resistance offered to the movement of the constituent particles of a rock-mass in the direction of cleavage-dip (in some cases) by the dead weight of the superincumbent mass;

[1] In my "Chemical and Physical Studies in the Metamorphism of Rocks," p. 56.

the relative value of the two modifying (in the case of a deep-seated rock-mass) the whole metataxic result. Mr. Harker applies the idea in some criticisms of a paper of General MacMahon's on the "Crumpled Culm-measures of Bude" (See GEOL. MAG. April, 1890).

Suppose a case in which the two forces were equal or nearly so. As long as this condition of things continued, the rock-mass would not shear at all; it would be in the condition which Professor Heim calls one of "latent plasticity," if no lateral movement in any direction were possible. This is equivalent to *hydrostatic pressure*, as I have pointed out (*op. cit.* pp. 47, 48). Compression of the mass might result, but not shearing. Until the limit of compressibility was reached, there must be internal friction, with the necessary thermal effect. As, however, the superincumbent mass became diminished by denudation at the surface (the lateral force continuing undiminished, or even increasing, from one or more causes), shearing in the direction of cleavage-dip would set in: friction again, with its thermal effect. The *quantity* of heat generated might be very large; but its wide distribution *in time and space* would certainly give us, in most cases, insignificant results as regards *intensity* of heat (temperature). *Op. cit.* p. 54. Even the low coefficient of conductivity of rock-materials would probably suffice to make dissipation of the heat-energy keep pace with its production; so that it may be questioned if a rise of temperature of any practical value, above that at which the rock-mass was maintained by the internal heat of the earth (or the proximity of a highly-heated mass of igneous rock), would ensue. While granting therefore that under conditions of intense compression (*op. cit.* p. 55) crystallization might be facilitated for chemical bodies already formed, it may be questioned whether the distinction, drawn by Mr. Harker for deep-seated masses, is a very real one.

The same question arises in connexion with the Rev. O. Fisher's treatment of the subject in the July Number of this MAGAZINE; and it yet remains to be shown that any considerable rise of temperature (sufficient to induce *chemical* change) can be postulated, or that much, if anything, beyond those changes which I have called "metatropic" (*op. cit.*), can be accounted for by dynamic action, except in rapid movements along "shear-planes" (*op. cit.* pp. 124–126).

Mr. Fisher suggests (p. 304) that the mechanical energy of the lateral pressure is resolved in part into the "molecular form of chemical action." What can this mean? If it means that new chemical compounds are formed, it is not molecular, but *atomic* energy, which is brought into play. We surely cannot suppose (indeed, we cannot, without rolling back the development of chemical theory a few decades at least, suppose) that chemical combination is the mere addition of one element or lower compound to another; that is to say, that the configuration of the resultant compound is the mere sum of the configurations of the antecedent molecules. It is something much more complex than that. But chemical combination must generate heat, the mechanical effect of which is to expand the mass, and so tend to discount the direct effect of pressure. The phrase "chemical action" is used, I think, a little too freely in many quarters, by people who make no pretensions to be considered chemists, as a sort of limbo to which to relegate points in petrology which they do not wish to explain.

May I add here a word of congratulation to Mr. W. M. Hutchings on his most valuable researches[1] in the fire-clays of Northumberland? He has given us a mass of facts which prove in a concrete instance, what I have contended for on general grounds (e.g. *op. cit.* pp. 53, 93[2]); and has simply "ripped up" the fallacy, *post hoc ergo propter hoc*, which underlies the assumption so often made, that the development of secondary minerals in cleaved slates and similar rocks is due to "dynamic-metamorphism"; since he has demonstrated their presence, to a large extent as the result of the ever-active laws of chemical change (aided by aqueous diffusion) in a rock which has undergone no dynamic metamorphism whatever.

NOTICES OF MEMOIRS.

I.—Scientific Results of Explorations by the U. S. Fish Commission Steamer Albatross. No. VII. Preliminary Report on the Collection of Mollusca and Brachiopoda obtained in 1887–88. By William Healey Dall, A.M. Proceedings of the National Museum, Vol. XII. No. 773.

THOUGH the greater part of this Report is devoted to a description of the species obtained, there are some introductory remarks which should not be overlooked by geologists on the conditions of life in the deep sea and on the nature of deep-sea deposits. Some of the most interesting of these notes relate to the "Archibenthal Region," as Mr. Dall terms the area which lies below the limit of Algæ and above the Abyssal Region. In this region "the action of erosion and solution . . . . seems less potent than in either the shallower or the deeper parts of the sea. In the shallower parts the excess of motion, in the deeps the excess of the eroding agent, may account for this." Some of the banks in these depths are formed in a way which should be noted, as perhaps accounting for the large quantities of broken shells often found in fine deposits which show little sign of currents. Mr. Dall speaks of "the habit of certain fishes, which exist in vast numbers, of frequenting certain areas where they eject the broken shells . . . . which they have cracked, swallowed, and cleansed of their soft tissues by digestion. . . . . Now, in examining critically large quantities dredged from the bottom, I have found the material from certain areas almost entirely composed of these ejectamenta."

In some 16 pp. of 'general considerations' on the Pelecypoda, Mr. Dall gives an account of the genesis of the molluscan hinge, and groups the bivalves into three orders, Anomalodesmacea, Prionodesmacea, and Teleodesmacea. It is impossible in a short abstract to

[1] *Vide* Geol. Mag. for June and July 1890.
[2] See also Appendix ii. Note T.

do justice to this classification; but the shell is recognized as modifying and in various ways being modified by the soft parts of the animal, and therefore as affording a safer basis for classification than any single anatomical character. C. R.

II.—The Geology of the Country around Ingleborough, with Parts of Wensleydale and Wharfedale. By J. R. Dakyns, R. H. Tiddeman, W. Gunn, and A. Strahan. (With Notes by C. Fox-Strangways and J. G. Goodchild.) 8vo. pp. 103. (London, 1890.) Price 2*s*.

THIS is an Explanation of Quarter-sheet 97 S.W. (50 New Series). It contains accounts of the Lower and Upper Silurian Rocks of Ingleton, Crummack and Horton-in-Ribblesdale; of the Carboniferous Limestone Series, Millstone Grit and Coal-measures; and of the Glacial and Post-Glacial deposits. Some dykes of Mica-trap penetrate the Lower Silurian rocks near Ingleton, and these intrusive rocks are described by Mr. F. Rutley.

III.—The Geology of Parts of North Lincolnshire and South Yorkshire. By W. A. E. Ussher. (Parts by C. Fox-Strangways, A. C. G. Cameron, C. Reid, and A. J. Jukes Browne.) 8vo. pp. 231. (London, 1890.) Price 2*s*.

IN this Memoir we have detailed descriptions of the strata, from the Keuper Sandstones and Marls of the Isle of Axholme, upwards to the Kimeridge Clay that underlies the Cretaceous escarpment. The several divisions of the Neocomian formation and of the Chalk are described, together with the Glacial and other superficial deposits. The Red Chalk is included at the base of the Upper Cretaceous. Long lists of fossils are given from the Jurassic rocks, and these are in part based on the work done by the Rev. J. E. Cross, of Appleby. The deposits of economic importance include the Frodingham Ironstone in the Lower Lias, and the Claxby Ironstone in the Neocomian. The Lincolnshire Limestone at Kirton-in-Lindsey yields a good hydraulic lime, which is sold as "Blue Lias Lime." A number of well-sections and borings are recorded in an Appendix.

IV.—On the Discovery of a Jurassic Fish-Fauna in the Hawkesbury Beds of New South Wales. By A. Smith Woodward.[1]

A LARGE collection of fossil fishes from the Hawkesbury-Wianamatta series of Talbralgar, New South Wales, has been forwarded to the author for examination by Messrs. C. S. Wilkinson and R. Etheridge, jun., of the Geological Survey of New South Wales. The final results will appear in a forthcoming memoir to be published by that Survey; but the investigation has already proceeded so far as to justify the announcement of the discovery of a typically Jurassic fish-fauna in Australia. Fine examples of the Palæoniscid genus *Coccolepis* occur, and this has previously been met with only in the Lower Lias of Dorsetshire, the Purbeck Beds of

[1] Abstract of paper read before Section C, British Association, Leeds, 1890.

Wiltshire, and the Lithographic Stone of Bavaria. A new fish allied to *Semionotus*, but with thinner, much imbricating scales, is also conspicuous; and another new form, allied to the Dapedioids, is remarkable from the presence of typical rhombic ganoid scales in the front half of the trunk and deeply overlapping cycloid scales over the whole of the caudal region. A *Leptolepis*-like fish, with a persistent notochord, seems to represent a third unknown generic type. Of *Leptolepis* itself there are many hundreds of individuals in a fine state of preservation. The fishes occur in a hard, ferruginous, fissile matrix, associated with well-preserved remains of plants.

V.—A Sketch of the Geology of Devonshire. By Townshend M. Hall, F.G.S. [Third edition, 1890. Reprinted from White's History, etc., of the County.]

In the Geological Magazine for August, 1879, we briefly drew attention to the first edition of this article, which gives a capital condensed account of Devonshire Geology. In the present edition the results of recent rescearches are noticed, and some accounts of the Mines and Mining are added. We observe, however, that the Bovey beds are classed as Miocene, and nothing is said of Mr. Starkie Gardner's contention that the beds are of Eocene age.

VI.—Preliminary Notes on the Palæozoic Elasmobranchs, *Pleuracanthus* and *Xenacanthus*, from the Lower Permian of Bohemia. By Dr. Anton Fritsch.[1]

The next part of the author's work, "Fauna der Gaskohle," which will probably appear before the close of the present year, is devoted to further investigations upon *Pleuracanthus* and *Xenacanthus*. Restored figures, first exhibited to the British Association at the Leeds Meeting, have been carefully prepared, being based upon the examination of no less than 200 specimens. The principal result arrived at is, that the three genera, *Orthacanthus*, *Pleuracanthus*, and *Xenacanthus*, are well characterized, and are all true Selachians. The skull is developed as a simple embryonic capsule, showing no ossifications or separate bones: it much resembles that of *Heptanchus*, and indicates that the three genera in question also belong to the Opistharthri of Gill. The branchial arches are likewise seven in number, as in *Heptanchus*. The median fins are embryonic in character, much like those of deep-sea Gadoids (e.g. *Bathygadus*). The pectoral fins are of the most primitive type in *Orthacanthus*, more advanced in *Xenacanthus*, and still more resembling the abbreviated fins of recent sharks in *Pleuracanthus*. There is no pelvic element, the basal part of the pelvic fin of each side being merely a fused mass of parallel cartilaginous rays. The claspers in the male closely resemble those of modern sharks, being formed by a modification of the dorsal or postaxial rays.[2] In the vertebral column, intercalaria are developed both in *Orthacanthus* and *Xenacanthus*.

[1] Abstract of paper read before Section C, British Association, Leeds, 1890.
[2] See figure in Zool. Anzeiger, No. 337 (1890).

REVIEWS.

I.—ON THE STRUCTURE AND DISTRIBUTION OF CORAL REEFS; ALSO GEOLOGICAL OBSERVATIONS ON THE VOLCANIC ISLANDS AND PARTS OF SOUTH AMERICA. By CHARLES DARWIN. [With a Critical Introduction to each Work, by Prof. JOHN W. JUDD, F.R.S.] Small 8vo. pp. 549. (Ward, Lock & Co., London, 1890.)

GEOLOGISTS are much indebted to the editor and publishers of the "Minerva Library," of which this work forms the eighteenth volume, not only for placing within the reach of all the classical writings of a pioneer like Darwin, but also for enlisting the co-operation of Prof. Judd in contributing three introductory chapters, which are invaluable to the general reader and to the student as yet on the verge of his subject. The book is practically three volumes in one, each with a special introduction; and though the type is necessarily small, it is remarkably clear, and the only evidences of cheap production are in some of the pictorial text-figures.

In the introductory remarks on Coral Reefs, Prof. Judd devotes five pages to a brief review of the circumstances under which Darwin's work was produced, and shows how the now well-known theory, propounded in that volume, at once commanded the almost universal assent of both biologists and geologists. The succeeding pages relate, with equal clearness, the most recent views on the subject, with sufficient references to literature to enable the ordinary reader to follow the somewhat extended controversy. The Professor points out that the objections to Darwin's theory have for the most part proceeded from zoologists, while those who have fully appreciated the geological aspect of the question have been the staunchest supporters of the theory of subsidence. He urges the undertaking of borings in coral reefs, adopting a suggestion of Darwin's; and he concludes by expressing the opinion that most readers will rise from the perusal of recent works on the subject fully convinced that, "while on certain points of detail it is clear that, through the want of knowledge concerning the action of marine organisms in the open ocean, Darwin was betrayed into some grave errors, yet the main foundations of his argument have not been seriously impaired by the new facts observed in the deep-sea researches, or by the severe criticism to which his theory has been subjected during the last ten years."

In a similar introduction to the work on Volcanic Islands, Prof. Judd gives an interesting *résumé* of some of the fundamental principles to the establishment of which Darwin's researches specially contributed. Von Buch's well-known theory of elevation-craters was satisfactorily disproved by the observations made in the Atlantic Islands; while the subsidence of crater-floors after eruptions, recently noted by Dana, among others, in the Sandwich Islands, was distinctly recognized in several cases. Darwin also observed the arrangement of volcanic vents along great lines of fissure; he inaugurated the study of extinct volcanoes dissected, so to speak, by the processes of denudation; and he seems to have been the first to form clear ideas as to the true relations existing between the crystalline igneous rocks of a district and their associated lavas. In short, "while much that is new and valuable has been contributed to geological science by more recent investigations, and many changes have been made in nomenclature and other points of detail, it is interesting to find that all the chief facts described by Darwin and his friend Prof. W. H. Miller have stood the test of time and further study, and remain as a monument of the acumen and accuracy in minute observation of these pioneers in geological research."

Darwin's "Geological Observations on South America" is a work that seems to have hitherto attracted less attention than either of the foregoing. Prof. Judd, however, is inclined to believe that the researches here detailed will eventually be regarded as one of the author's chief titles to fame. It was in this volume that Darwin first emphasized the imperfection of the geological record; at the same time enunciating the important conclusion that each great geological period has exhibited a geographical distribution of the forms of animal and vegetable life, comparable to that which prevails in the existing fauna and flora. It was here, too, that uniformitarian views on the volcanic phenomena of past ages were first clearly expounded, with abundant illustrations. Finally, Darwin's study of the schists and gneisses of South America led to the earliest recognition of the intimate relationship existing between planes of foliation and thrusts during elevatory movements—thus anticipating some of the most recent conclusions deduced from researches among the metamorphosed rocks of Scotland, Norway, Saxony, and other areas.

The volume is provided with a good index of 30 pages, and will be one of the most welcome additions to a working geologist's library that has appeared for some time.

II.—Prof. W. B. Scott on the Oreodonts.

Beiträge zur Kenntniss der Oreodontidæ. By W. B. Scott. Morphol. Jahrbuch, Vol. XVI. Part 2. Illustrated. (1890.)

THIS memoir is a very valuable contribution to our knowledge of that remarkable family of North American Artiodactyle Ungulates commonly known as Oreodonts, in which the author gives in a concise form all the important features of their osteology. Judging, indeed, from the skeleton represented in the first of the plates accompanying the memoir, it may be inferred that our knowledge of the skeletal anatomy of the type-genus of the family is now practically complete, and as well known as that of existing mammals. The remarkable variations exhibited by the skulls of the different genera are admirably illustrated in the other plates; and we may especially call attention to the tendency to the development of facial vacuities in the skulls of the more specialized forms.

The typical Oreodonts or Ruminating Hogs, as they were not inaptly termed by their original describer Prof. J. Leidy, occur in the North American Miocene, from the Loup-Fork to the White River beds; but they are also represented in the Uinta or Upper Eocene, while *Helohyus* of the Bridger or Middle Eocene should perhaps be also included in the family.

Professor Scott takes as the chief character of the family the circumstance that the lower canine tooth resembles the incisors, while the form and function of the canine is assumed by the first lower premolar. The family is divided into three subfamilies as follows, viz. :—

I. Upper molars with five crescents—*Protoreodontinæ.*
II. Upper molars with four crescents.
   1. Orbits closed, a lachrymal depression, no diastema, all the premolars simpler than the molars—*Oreodontinæ.*
   2. Orbits open, no lachrymal depression, a diastema, the last premolar molariform—*Agriochœrinæ.*

The Protoreodonts are the earlier and more generalized forms, and the presence of five crescents on their upper molars suggests affinity with the *Anthracotheriidæ* and *Anoplotheriidæ.* It is indeed curious to observe that the reduction in the number of crescents on these teeth in the two more specialized subfamilies of the Oreodonts is precisely paralleled among the Anthracotheroids by the specialized Siwalik genus *Merycopotamus*, which has only four such crescents.

We hope that the learned author of this important memoir will see his way to treating other groups of extinct American mammals in the same masterly manner. R. L.

III.—Professor H. Credner on Permian Labyrinthodonts and Reptiles.

Die Stegocephalen und Saurier aus dem Rothliegenden des Plauen'schen Grundes bei Dresden. By Hermann Credner, Zeitschr. deutsch. geol Ges. Vol. XLII. (1890). Illustrated.

In this memoir Professor Credner continues his elaborate and interesting investigations into the Labyrinthodont and Reptilian fauna of the Rothliegendes of the neighbourhood of Dresden; the species treated of in the present fasciculus being, if possible, of more than usual interest.

The first section of the memoir before us is devoted to the description of the skeleton of the Labyrinthodont genus *Hylonomus*, from which the author regards *Hyloplesion* of Fritsch as inseparable. The members of this genus comprise minute forms common to both the Old and New Worlds, the detailed anatomy of which can only be worked out by those who have the abundant material and exemplary patience which it appears to be the good fortune of the author to possess. The plates and woodcuts with which the memoir is so richly illustrated speak for themselves as to the care with which these details have been worked out. One point, however, strikes us as requiring further illustration, and the author will perhaps take an early opportunity of expressing his views on the subject. The point to which we allude is that, according to Dr. Fritsch's definition of this group of Labyrinthodonts, the whole of the body was invested with scutes, whereas our author only mentions a ventral armour.

Of still more interest is the genus *Petrobates*, another small form presenting such a marked general resemblance to *Hylonomus* that its remains have hitherto been confused with those of that genus. It differs, however, among other characters, by the smaller skull (which does not appear to have been of a Labyrinthodont type), the longer tail, and the replacement of the Labyrinthodont ventral buckler by a system of abdominal ribs like those of the existing Rhynchocephalian genus *Sphenodon*. Its Labyrinthodont affinities are, however, displayed by the attachment of the pelvis to the vertebral column by means of only a single sacral vertebra. Since, however, this feature is exhibited by the genus *Pariasaurus*, which appears to be a reptile, although exhibiting marked Amphibian affinities, it affords no argument why *Petrobates* should not likewise be included in the Reptilia.

Dr. Credner considers that *Petrobates* connects *Hylonomus* with those Rhynchocephalian reptiles from the same deposits which he has described in earlier fasciculi of the same memoir under the name of *Cadaliosaurus* and *Palæohatteria*; and the result of his latest researches seems to establish, beyond the possibility of doubt, the intimate affinities existing between certain groups of the Labyrinthodonts and the earliest Rhynchocephalians.

The memoir concludes with the description of the skeleton of a small rhachitomous Labyrinthodont named *Discosaurus*. We would, however, point out to Dr. Credner that this name had been employed at an earlier date by Prof. Leidy for a Sauropterygian, and we would therefore suggest that he should take an early opportunity of proposing a new term.

We shall look forward with interest to further contributions by the author on the subject on which he has already thrown so much new light.
R. L.

IV.—Holm, Gerhard. Om förekomsten af en Caryocrinus i Sverige. Sver. Geol. Undersökn. Ser. C. No. 115, pp. 14, 15. (Stockholm, 1890.)

Of the interesting genus *Caryocrinus* but a single species has been described, and this species, *C. ornatus*, Say, has only been found in N. America. There it occurs in the Niagara and also, according to S. A. Miller, in the Clinton group. These groups are regarded as synchronous with the British Silurian from the Wenlock Limestone to possibly as low as the Tarannon Shales.

In the present paper Dr. Holm records the find of a new species of *Caryocrinus* in the lower layers of the Leptæna-kalk on the west side of the Lissberg near Gulleråsen in Boda, a district of Dalecarlia. The Leptæna-kalk has not been traced beyond Dalecarlia, but on palæontological grounds it is referred to the Upper Ordovician. In the present instance among the associated fossils are *Cyclonema* *angulatum*, *Orthis biforata*, *Athyris Portlockiana*, *Strophomena corrugatella*, *Illænus Linnarssoni*, *Favosites*, *Halysites*, *Ptychophyllum*, *Sphæronis oblonga*, *Eucystis* sp., and *Caryocystis* sp. The Cystidea are numerous and the rock is filled with stem-ossicles which Dr. Holm, after the curious custom of collectors, thinks it necessary to ascribe to Crinoidea.

Of *Caryocrinus* only one specimen has been found here. This differs from *C. ornatus* in the following points: the arms are more robust and start lower down on the radials, giving rise to a zone of protuberances on the cup, the plates of the tegmen are not quite the same, and the anus[1] lies nearer the centre.

Thus *Caryocrinus* might appear to have originated in European seas, rather than those where it subsequently flourished; but the remarkable fact that no specimens have been found in any Silurian rocks of Europe, often so prolific in Pelmatozoa, suggests another hypothesis. The genus may have developed during Ordovician times in an area that is still beneath Atlantic waters; the few individuals that ventured to Scandinavia may have found those seas unsuited to them, while others at a later date migrating towards America may have been the ancestors of those now preserved so abundantly in the State of New York. F. A. B.

V.—Revision of a Genus of Fossil Fishes — *Dapedius*. By Montagu Browne, F.G.S. Trans. Leicester Lit. and Phil. Soc. Vol. II. pp. 196–203, Pl. I.

THIS is the first instalment of a Memoir on the Liassic Ganoid *Dapedius*, in which the author proposes especially to revise the species occurring in Britain. After a preliminary review of the literature of the subject, *Dapedius dorsalis* (Agass.) is discussed in detail, the supposed species, *D. monilifer* and *D. striolatus*, being merged with this form, as presenting no satisfactory points of distinction. Dr. Traquair's restoration of the head of *Dapedius* is copied upon the plate, with the addition of some rough figures of teeth and scales, the latter inadvertently turned upside down.

VI.—A Zoological Pocket-Book. By Dr. Emil Selenka. Translated by J. R. Ainsworth Davis, B.A. (Charles Griffin & Co., 1890.)

THE plan which forms the basis of this little volume is an admirable one, and students will welcome so concise a compendium of Zoological classification. There is a laudable attempt, also, to incorporate some of the more striking results of the palæontological aspect of the subject. The brief definition of each group is accompanied by the names and some particulars of leading types; and the book is interleaved throughout for MS. notes and memoranda. We can only regret, from our point of view, that

[1] Dr. Holm calls it the mouth; but this is probably due to a too close adherence to Professor J. Hall's description, and need not be taken as a serious expression of opinion.

the work is so completely behind the times. Zoologists and Comparative Anatomists of the modern school are certainly more alive to the importance of palæontological considerations, than were their predecessors, not many years ago; but few at present attempt any systematic study even of the literature of the subject. To refer only to the Vertebrata in the volume before us, and commencing with the fishes, we may remark that *Amia* does not date back to the Cretaceous period, that *Pycnodus* was shown thirty-five years ago to be exclusively confined to the Eocene, and that *Lepidotus* and *Amblypterus* are totally unknown in the Kupferschiefer. *Proterosaurus* still remains among Lacertilian Reptiles, notwithstanding recent memoirs; and *Dicynodon* is unaccountably placed among the Dinosauria, while no mention whatever is made of the all-important Theromora. The old "order Enaliosauria" still survives; and once more the erroneous statement about the opisthocœlous character of the vertebræ of *Steneosaurus*—a permanent institution in German text-books of "Zoology"—is repeated. Among Prototherian Mammals there is no allusion to the recent discovery of true teeth, while the Jurassic types are completely omitted; and *Microlestes* is only incidentally mentioned as a kangaroo ("springing marsupial")! *Diprotodon australis* is also described as a "springing marsupial"; and it will be news to some that *Thylacoleo* is an intimate relative of the Thylacine. Among Edentates, *Glyptodon* is described as an "insectivorous form"; and, to proceed to higher groups, it may be remarked that all modern researches which have led to such striking results, especially with reference to the Ungulata and Carnivora, are ignored. The Outlines of Distribution, appended by the Translator, appear to us to be more completely up to date than any other part of the volume, and it is to be hoped, that before another edition appears, some attempt will be made to renovate the whole.

VII.—Proceedings of the Cotteswold Naturalists' Field Club for 1889–90. Vol. X. Part I. 1890.

GEOLOGY continues to occupy a large share of attention from the members of this Club. The address of the President, Mr. W. C. Lucy, is supplemented by "A Slight History of Flint Implements, with especial reference to our own and adjacent areas." There is no reliable evidence of any Palæolithic implements having been found in the district, but a number of Neolithic celts, arrowheads, and scrapers are noted, and some of these are figured in three plates.

The Rev. F. Smithe, LL.D., furnishes some "Observations on Celestite." He remarks that this mode of spelling the name of the mineral, advocated by Dana, is now adopted in the mineralogical collection of the British Museum, in preference to Celestine; words terminating in *ine* being properly restricted to the science of Chemistry. He gives a particular account of the mineral and of its mode of occurrence, not only in Gloucestershire, but in various parts of the world. The cuttings made during the construction of the Midland and South-Western junction-railway between

Cirencester and Andoversford, are described in detail by Prof. Allen Harker and Mr. S. S. Buckman.

Prof. Harker's contribution is "On the Sections in the Forest Marble, and Great Oolite Formations, exposed by the new railway from Cirencester to Chedworth." The diagram he gives is unfortunately very much cramped, but it serves as an index to the localities mentioned. Mr. Buckman gives an account of "The Sections exposed between Andoversford and Chedworth: a comparison with similar strata upon the Banbury line." These sections are mainly in the Inferior Oolite, whose many local subdivisions are duly noted. There is also a short paper, accompanied by a plate, by Mr. E. Wethered, "On the Occurrence of Fossil Forms of the Genus *Chara* in the Middle Purbeck Strata of Lulworth, Dorset."

CORRESPONDENCE.

MR. SOMERVAIL'S CONTRIBUTIONS TO THE PETROLOGY OF THE LIZARD.

SIR,—During the last three years the GEOLOGICAL MAGAZINE has been augmented by four communications from Mr. Somervail on the Petrology of the Lizard. These I have refrained from noticing (beyond making in one case a brief protest), because I wished to re-examine the whole district before writing anything more on the subject. Last summer I had the advantage of spending some time at the Lizard in company with General McMahon and the Rev. E. Hill, and we hope to bring the results of our examination before the Geological Society during the present session.

To point out the errors in observation and inaccuracies of induction in Mr. Somervail's papers would occupy far too much space in the MAGAZINE and weary the patience of your readers. I must content myself with a general expression of opinion as to the dominant idea in each communication. First, "On a Remarkable Dyke in the Serpentine of the Lizard."[1] This is a group of separate dykes, diorite and granite, the latter containing some fragments of an older rock, and associated with a quartz-felspar vein; it is no part of the "granulitic group," as I have defined it, and gives no support to Mr. Somervail's notion of rocks of different composition segregating from one magma.

(2). "On a Breccia and an Altered Schist at Housel Cove, Lizard."[2] Here the ordinary hornblende schist has been cut by a dyke, and a fault running nearly along one surface of junction has brecciated the latter. Perhaps this dyke differs a little in composition from the types which are common at the Lizard, and there is a good example of fault breccia. As usual both rocks are rotten, but the section leads to no particular conclusions.

(3). "On the Greenstone and Associated Rocks of the Manacle Point."[3] This section is a difficult one, and there are points which

[1] GEOL. MAG. 1888, Dec. III. Vol. V. p. 553.
[2] GEOL. MAG. 1889, Dec. III. Vol. VI. p. 114.
[3] GEOL. MAG. 1889, Dec. III. Vol. VI. p. 425.

must be left for further work. On one, however, I feel quite clear, namely, that the relations of the rocks have been completely misunderstood by Mr. Somervail.

(4). "On the Nature and Origin of the Banded Structure in the Schists and other Rocks of the Lizard District."[1] As this subject will form an important part of our paper, I content myself with observing that I can find no ground for Mr. Somervail's hypothesis of segregation, as he applies it. I question both the accuracy of his statements and the validity of his inductions. Doubtless before writing upon these difficult subjects, Mr. Somervail has trained himself by careful study both of rock-structures under the microscope, and of rock-relations in less complicated districts of other regions; but if so, I am utterly at a loss to understand his principles of interpretation and his methods of reasoning.

T. G. Bonney.

BANDED ROCKS OF THE LIZARD.

Sir,—Mr. Somervail in his paper on the Lizard rocks, published in your last issue, advances the theory of segregation to explain all the phenomena displayed by the eruptive rocks of that interesting locality, but he does not favour us with any evidence in support of his theory, and he omits to explain facts that seem incompatible with it. That such rocks as peridotite, gabbro, diorite, basaltic, and felspathic traps, and granite—rocks of well-defined species differing from each other in mineralogical contents, structure, and chemical composition (points that imply genetic differences)—should be formed on the spot by segregation from a "common magma," is sufficiently startling to the petrologist; but when we find, as competent observers have found, that these rocks cut each other in well-marked dykes following each other in a regular sequence, and that each of the principal intruders carries along with it sharp fragments of the rocks through which it has intruded, the hypothesis involves the rejection of every canon of interpretation hitherto relied on by field geologists.

When one sees diverse igneous rocks cutting across each other in a way that implies differences in their order of eruption; and when one finds the lines of demarcation between these *successive* eruptions so sharp that even thin slices examined under the microscope show a sudden transition from a rock of one chemical and mineralogical composition to another of different chemical and mineralogical composition, it seems as unreasonable to a petrologist to attribute the formation of these definite and distinct species to segregation *in situ* as it would be to attribute the jaw-bone and teeth of a well-known quadruped, found in a bed of marl, to the fortuitous segregation of the carbonate of lime.

The above-mentioned rocks not only cut each other with a definite sequence, but they preserve their individual characteristics, whether

[1] Geol. Mag. 1890, Dec. III. Vol. VII. p. 515.

they occur in veins a quarter of an inch thick, or in masses many miles wide.

Science is not advanced by the dreaming of dreams—to make progress we require evidence culminating in proof.

20, Nevern Square,
10*th November*, 1890.

C. A. McMahon.

PROF. PRESTWICH, F.R.S., ON THE ELEVATION OF THE WEALD.

Sir,—I am much obliged to Prof. Prestwich for drawing attention to an expression in my "Note on the Elevation of the Weald" (Geol. Mag. September, 1890), to which I feel bound to say *peccavi.* The fact is, when that paper was written, I was ignorant of the view which the Professor had put forward so long ago as 1858 in a paper, of which he has since been good enough to send me a copy. When my 1883 paper was written, the only published statement of Prof. Prestwich's view on the geological data of the Wealden elevation, which I had before me, was that contained in the published abstract of a paper read (in my hearing) before Section C of the Brit. Assoc. at York in 1881. I am sorry I was misled by this; and the more so as it was criticized by me more than once in the 1883 paper, to which the Professor refers. A copy of that paper was sent to him at the time of its publication; but, strange to say, in the Professor's letter (which is now before me) acknowledging the receipt of it (which seems to have been lost sight of since), and offering some remarks upon some points in it, no notice was taken of my criticisms on the York paper. Was it very extraordinary that under such circumstances I was lulled into the belief that I had correctly interpreted the statements contained therein?

Prof. Prestwich will kindly allow me to refer to some remarks I ventured to make in the discussions of Parts II. and III. of his recent great paper, "On the Westleton and Mundesley Beds, etc.," the substance of which is published in the Journal of the Geological Society. These indicate, I think, sufficiently my position with regard to this question.

As to Mr. Clement Reid's paper in "Nature" in 1886 (not 1888), I did not feel the necessity of pointing out (what must be obvious to any one who looks at it), that it was a "friendly corroboration" of Prof. Prestwich's view expressed years before.

The argument for contemporaneity, "on the ground of approximate equality of altitude above the sea," I had no idea of saddling upon Prof. Prestwich in particular. I mentioned it as the only argument I had heard put forward by geologists, with whom I had discussed the question, after I suggested in the pages of the Geol. Mag. (1888) a different view to those generally held, from an examination of the principal sections "in the field."

As regards the "larger and more theoretical questions" raised in my paper, I think I have sufficiently indicated the authorities which have furnished the data from which my inferences are drawn. I am, of course, allowed to draw my own conclusion from the Professor's dignified refusal to consider them.

I can only express again my regret that I did not re-write the objectionable passage which has called forth this friendly protest from one for whom I entertain the most sincere regard; yet I think that results arrived at independently have a value, even if they are not "novel."

A. Irving.

Wellington College, Berks.

THE ELEVATION OF THE WEALD.

Sir,—In Mr. H. W. Monckton's idea as to the "retreat of the sea" in connexion with the marine abrasion of the Weald anticlinal (see Geol. Mag. September, 1890, p. 395), he has got a glimpse of what has been obvious enough to most students of geology for the last quarter of a century. For at least that period of time Sir Andrew Ramsay's view of the marine abrasion of the original arch of the Weald anticlinal, followed by atmospheric waste and erosion (determining the present features of the country) has been before the world in his valuable and suggestive work, "The Physical Geology and Geography of Great Britain." Mr. Monckton seems to consider the area of the *deposition* of the Wealden series to have been approximately conterminous with the present area known as the Weald. In the light of what we know of a great series of Tertiary movements in Central and Western Europe, it must be rash in the extreme to assume that the present relations of sea and land are any index of what they were in even later Mesozoic time. The statement, that, "from some undetermined period [extending at least as far back as the Purbeck, *loc. cit.*] until the formation of the Gault the south-east of England was an area of depression, *and the progress of depression was more rapid upon an east and west line which now forms the anticlinal of the Weald than either to the north or south of it*," is in flat contradiction to Prof. Green's constructive sketch of the old Wealden Estuary (see "Physical Geology," pp. 294–6). I commend this to Mr. Monckton's attention.

In his concluding paragraphs it seems he has done me the honour to reproduce partly some arguments as to the non-commensurate elevation of the Weald, which I put before the Geological Society in June last at a meeting at which he was present. These arguments are given in a more complete form in my paper in the Geol. Mag. for September, 1890, pp. 405–6.

A. Irving.

Wellington College, Berks.

OBITUARY.

ORAZIO SILVESTRI.

We regret to record the death of this distinguished Sicilian Geologist and Chemist, which occurred at Catania on August 17, after much suffering. Prof. Silvestri has contributed largely to our knowledge of the workings and chemistry of Etna, and to the general geology of Sicily, while his masterly paper on the genus *Nodosaria*, and his interesting papers on the works of Soldani are of great interest and value to students of the Foraminifera.

Erratum.—In Geol. Mag. November, 1890, p. 501, fourteenth line from top of page, for "These are," etc., read *There* are, etc.—Edit. Geol. Mag.

INDEX.

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