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

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January, 1880.

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Fig. 1.
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OF THE
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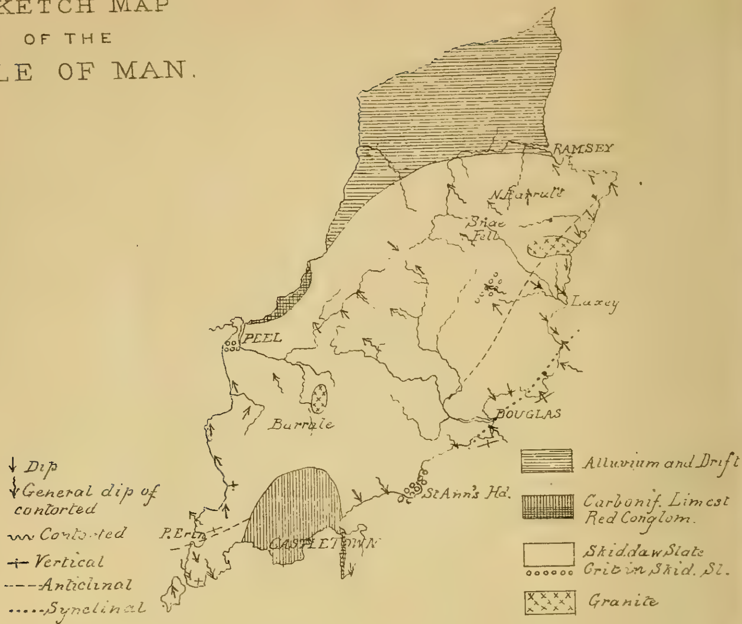


Fig. 2.

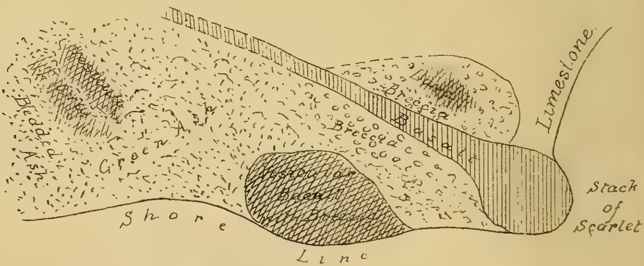
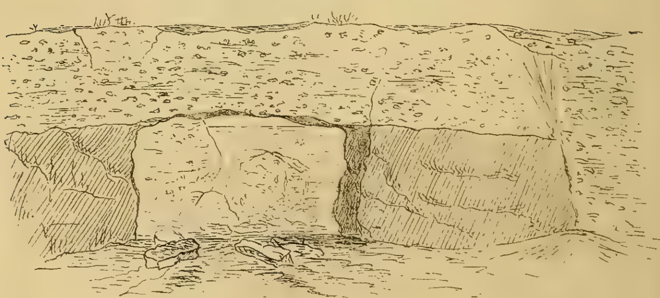


Fig. 3.



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To illustrate the Rev. J. Clifton Ward's paper.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VII.

No. I.—JANUARY, 1880.

ORIGINAL ARTICLES.

I.—Notes on the Geology of the Isle of Man.

By the Rev. J. Clifton Ward, Assoc. R.S.M., F.G.S., etc.

(PLATE I.)

THE following notes have been made during a few weeks' holiday in the Isle of Man, and my special object is to notice those points which have a bearing upon the geology and physical history of the neighbouring Cumberland mountains. For many years I have, from time to time, looked across to the hills of Mona's Isle, regarding them as a portion of the Cumbrian group standing aloof from their brethren, and often have I wished to carry my hammer amongst them. My wish has at last been fulfilled, but the bad weather of the coldest of summers has prevented the observations made being as full as I had intended. Such as they are I offer them.

At the outset I would wish to add my testimony to the careful and accurate observations of the Rev. J. G. Cumming, as recorded in his work on the Isle of Man, made when geological science was far less advanced than at present.

My remarks shall be grouped under the heads of the various formations represented, and a final glance taken of the physical history of the island as contrasted with that of the Cumberland mountains.

Skiddaw Slates.

One of my chief objects in examining the geology of the Isle of Man was to see whether the group of rocks supposed to answer to the Skiddaw Slates of Cumberland threw any light upon the subdivisions of these latter. In previous papers I have pointed out that the so-called Skiddaw Slates may be divided into the following parts, commencing with the highest member:—

4. *Skiddaw Slate proper* (black clay-slate of Skiddaw).
3. *Coarse Grit.*
2. *Black Iron-stained Slates.*
1. *Thick-bedded Sandy and Gritty Series* (of Grasmoor and Whiteside).

The Grit No. 3 I have thought to represent the Arenig Grit of N. Wales, which it resembles in character and, so far as can be ascertained, position. No. 4 would then stand for the Arenig Slates, No. 2 for the Tremadoc Slates, and No. 1 represent the Lingula

Flag Series. Moreover, No. 4 is succeeded *conformably* by the Volcanic Series of Cumberland, but in the south-western corner of the Lake District the slates of this division are absent, and the volcanic ashes immediately succeed the grit, and are conglomeratic in character, rounded pebbles and blocks of the grit being bedded with the ashy material.

Trusting that further light might be thrown on these subdivisions by an examination of the Skiddaw Slates of the Isle of Man, I began by seeking the uppermost beds described by Profs. Harkness and Nicholson as conformably underlying volcanic ash-beds occurring at Douglas and Clay Heads. But I have not been able to satisfy myself that there are any volcanic beds answering in age to those of the Lake District, and on writing to Prof. Nicholson to inquire more particularly as to the ashy members of Douglas Head and Clay Head, he replies, "So far as my own imperfect recollection serves, it is quite possible that we may have mistaken light-coloured gritty bands in the Skiddaw Slates for ashes." I think that this must have been the case, and that for two reasons. In the first place, I could find no beds with decided ashy characters, but the sandy and gritty characters prevail in the localities named. In the second, at both places the dip is to the W.N.W., and any beds occurring at either Head must, if they be conformable, *underlie* that portion of the Skiddaw Series. In the case of the Douglas Head rocks, the dip, though very high—sometimes nearly vertical—is persistently westwards for three-quarters of a mile, from behind the Dock to the Head itself, and therefore any conformable volcanic rocks occurring at Douglas Head would *underlie* a great thickness of the Skiddaw group. After having examined the fine cliff-sections all round the island more or less carefully, and having traversed the mountain groups in several directions, I have failed to find any portion of the Volcanic Series of Cumberland represented. At the same time it might be rash to say that none of the thick flaggy and gritty-looking beds so largely developed have mingled with them fine ashy material; this may still be the case, and yet the whole belong to the series of marine sedimentary deposits known as the Skiddaw Slate group.

Being disappointed in obtaining a defined upper limit to the slaty series, my next object was to light upon some defined band of sandstone or grit which could be traced across the island, and thus give an horizon. I hoped, indeed, to meet with my Skiddaw or Arenig grit. It is necessary to state that all the south-eastern portion of the island from Port St. Mary north-eastwards to the central valley between Crosby and Douglas, is for the most part devoid of good sections, except along the coast-line; also that large portions of the mountain area north of the central valley are very sectionless, great spreads of drift sometimes sweeping up the several valleys, and oftentimes the mountain slopes being uninterruptedly grassy.

Upon the small map (Fig. 1) I have marked the general direction of the dips observed; these are for the most part at a considerable angle, and often nearly vertical.

The rock occurs in four forms. 1. As a coarse thick-bedded sandstone or grit, slightly conglomeratic in parts. 2. As more or less thickly-bedded flags of a grey colour within but often irony on the outside. 3. As black slate frequently flaggy in character, and occasionally cleaved. 4. As soft black shale, not unlike coal-measure shales. All these forms also recur in the Lake District Skiddaw Slate group. No. 1 is perhaps best seen at St. Ann's Head, four miles south of Douglas. No. 2 is well represented at Douglas, and furnishes most of the building material of the town. No. 3 may be well seen about South Barrule slate quarries, where cleavage is developed, and on Spanish Head, where the black flags, lying almost flat, are quarried for gate posts. No. 4 occurs in the upper parts of Glen Meay (west of South Barrule), and other places,

It would be unsafe to offer any decided opinion upon the divisions of the Skiddaw Slate in the island without having made a detailed survey of the whole, and still more so to point to certain parts as the equivalents of Lake District divisions. That gritty beds occurring at St. Ann's Head and on Carn Gerjoil (marked in round dot pattern on the map) resemble on the whole the Skiddaw or Arenig Grit previously alluded to, is but imperfect evidence at the best. This much is however to be said in favour of their identity, that the slates of the Snae Fell range, extending from N. Barrule, through Snae Fell, to Greeba and S. Barrule, have a general north-westerly dip, and much resemble the black slates of the Cumberland Skiddaw. The sandy and gritty beds of St. Ann's Head dip eastwards, while those on Carn Gerjoil dip westwards. It may be that they respectively represent the two sides of an anticlinal which runs from a little south of Ramsey to a little west of Douglas. On the other hand, it is possible that some large fault runs through the nearly east and west central valley, between Douglas and Peel. Gritty bands again occur south of Peel. Prof. Nicholson also describes a quartz rock with pebbles three miles west of Ramsey dipping to the north-west, and containing black shale bands, and a little south of Crosby station I observed a thick bed of quartzite dipping west under black shale. Very likely, indeed, there are gritty beds on several different horizons, and, indeed, on the east of the island especially, the beds appear much more sandy than is the general character of the series in the Lake District.

A *broken* line from south of Ramsey to near Douglas indicates the general direction of a marked anticlinal; and a *dotted* line from the south of Laxey to Douglas, a marked synclinal. An anticlinal again appears running through the harbour of Port Erin, and on the north side of this, especially at Bradda Head, the rocks are beautifully contorted, though showing a general north-west dip; on the south side, however, about Spanish Head, the beds are almost horizontal or dip slightly seawards, giving rise to large slips and broken ground known by the name of the chasms. With the chance of a large fault between Douglas and Peel it is hard to parallel the rocks north and south of Port Erin with any particular portions of those in the north of the island. The strike of the black flaggy slates of Greeba and St. John's seems however to be continued across the valley. On the whole it appeared to me that the Skiddaw Slates of the Isle of Man throw no light on the divisions of the same series in the Lake District; and probably, when the island is minutely surveyed, all defined bands being traced, more help will be derived *from* the Lake District than given by the Isle itself.

Carboniferous.

The various beds of the Carboniferous Limestone Series are very minutely described by Mr. Cumming, and I would here only offer some remarks, (1) on the conglomerate at the base, and (2) on the volcanic rocks interbedded with the limestone.

1. *Basement Conglomerate.*—Although Mr. Cumming gives to this conglomerate and its associated sandy beds the name of Old Red, it should be specially noted that at the early date at which he wrote he recognized the complete conformity between these beds and the overlying limestone.

It is scarcely necessary for me to notice the paper by Mr. Howorth published in the Geological Magazine, 1877, pp. 411 and 456, as his endeavour to lay bare the supposed errors made by Mr. Cumming has been met by a paper in the May number of the same Magazine for 1879, by Mr. G. H. Morton. It is, however, preposterous that one who confesses himself to be "not an experienced geologist" should so confidently assert that the conclusions drawn, after long and careful study, by one who *was* an experienced geologist, were erroneous. Nothing could be clearer than that the conglomerate beds underlie the Carboniferous Limestone, that they are almost wholly made up of sandstone or quartzite pebbles, and that the beds do not represent boulder deposits of the Glacial Period.

On the western side of Langness the conglomerate may be well studied in its relations to both underlying and overlying rocks. At low tide the complete conformity of the conglomeratic beds dipping westwards, with the overlying limestone, may be well seen, and near high-water mark the complete unconformity of the conglomerate with the underlying Skiddaw Slate is also admirably shown. This is especially the case where an arch has been worn through the slate, the upper part consisting of conglomerate; close by is a little fault, throwing the conglomerate against the slate (see Fig. 3). For the most part the pebbles lie with their long axes in the planes of bedding, and so far as I remember it was but exceptionally that the formation assumed anything of the appearance of a true glacial or boulder deposit.

The red sandstone cliffs north of Peel contain conglomeratic portions, and dip to the north-west. These beds have been described by my friend Mr. Horne,[1] who parallels them with the Calciferous Sandstone series of Scotland.

2. *Volcanic Rocks of Carboniferous Age.*—The coast-line between Castletown and Poolvash is perhaps the most interesting part of the

[1] Trans. Edin. Geol. Soc. vol. ii. pt. 3, 1874.

island to the geologist, for here he sees a small ancient volcano dissected and laid bare. I was at once reminded of some of the ash-necks of Carboniferous age occurring just north of the Scottish border. The rough plan (Fig. 2) will help to illustrate the following remarks. The Volcanic rocks extend from Scarlet Point to Poolvash, a distance of about a mile and a quarter, and consist almost wholly of ash and breccia, intersected by dykes of basalt. The Stack of Scarlet shows the finest development of basalt, and from this point there runs a dyke of the same in a W.N.W. direction, which, when best seen, is about fifty feet wide, but westwards it is much hidden under cover of cultivated ground. With regard to this line of intrusive basalt, there cannot be a doubt, I think, but that it represents an original line of eruption, the part nearest to the Stack being the spot where the volcanic fires first reached the surface, and where the vent became finally choked with large ejected blocks and scoriæ, the basaltic lava welling up through a central fissure, and flowing over the volcanic breccia as it is seen to do upon the east side of the dyke. A little farther west along the shore the greenish ashy material is less coarse, and becomes distinctly stratified, this representing the matter falling outside the vent and becoming rudely bedded beneath the shallow sea. Just before reaching the bedded ash, other portions of the lava-flow may be seen overlying the ash, and exhibiting a very vesicular structure in bands. Nearer to Poolvash the ash is interstratified with limestone, both the grey and the black Posidonian band, so that there can be no doubt but that the eruption partook of a submarine character.

A second mass of vesicular basalt, with brecciated portions, occurs just W. of Scarlet Point; it does not, however, seem to extend as a dyke, and its southern margin is hidden by the shore-line.

The order of events would seem to have been this: During the deposition of the grey limestone and the bands of black calcareous mud, a vent was opened out through the bed of the sea—probably but shallow—from which many large blocks were ejected, the most of them falling back into the rent, while the smaller material fell at a little distance from the centre of eruption, and became roughly stratified and partly mixed up with the calcareous deposits. Then lava welled up from the vent (about Scarlet Point), forced its way through a fissure extending some distance westwards, cutting through the previously-deposited ash, and finally flowing over the ash in the form of a vesicular lava-stream, only small patches of which are now visible.

The limestone immediately north-east of Scarlet Point is much altered, and near the junction with the basalt, as Mr. Cumming has observed, it is not always easy to distinguish between the two rocks. Some small dykes or threads of basalt among the limestone bands are very interesting in their course and behaviour. Between the Stack and the lime-kilns the limestone is also finely arched in places, and I was interested to observe the minute cracks extending *along* the summit of one arch, for the most part filled with carbonate of lime. The same fine curving in the thick limestone beds may be seen along the shore north of Derby Haven; Mr. Cumming connects these curves with the intrusion of igneous rocks beneath, and not with general movements of the whole series of deposits, as I should be more inclined to do. The two—igneous intrusion and general contortion—may well, however, be intimately connected.

With regard to the former greater extension of the Carboniferous rocks, it is difficult to say much. That they once extended well over the lower south-eastern portion of the island there can be but little doubt, and there is every reason to believe that the red sandstones of the shore-line north of Peel dip beneath limestone occurring a short way out to sea, but it would be rash to assert that all the older rocks were once covered by beds of Carboniferous age, and, as seems very probable in the Lake District area, a ridge of Silurian rocks may have stood well up above the sea during the whole of the Carboniferous period, and around this early form of the Isle of Man the conglomerates were piled up and the limestone beds formed.

Post-Carboniferous.—The island contains no records, not even of the most fragmentary description, of any of the geological periods from the Carboniferous to the Glacial epoch. As in the Lake Country area, so here, during this long period of time, denudation was probably at work, in all its various forms, carving out the island from the Old Silurian nucleus and Carboniferous framework. At some period after the close of the Carboniferous, elevation and faulting must have occurred, by which the present relative positions of Carboniferous and Silurian rocks were attained, but it is impossible to say certainly when this happened or whether it may not have occurred more than once. Analogy with the neighbouring Lake District area would suggest that these movements mainly took place soon after the close of the Carboniferous Period or in early Mesozoic times.

There is every reason to believe that the island had much of its present form at the commencement of the Glacial Period, as was the case with the land in Cumbria, nor was that form much modified during glacial times.

The glacial deposits also do not differ from those of Cumbria. There is the usual stiff clay with stones, of probable ice-sheet origin, and stratified sands and gravels of generally more modern date than the clay. These sandy deposits, especially developed at the north end of the island, have yielded many remains of shells, and are, undoubtedly, for the most part marine in origin. A few miles south of Point of Ayre these sandy beds are contorted and even inverted, possibly by the grounding of icebergs. Moreover, the glacial drift runs up into the interior of the island in the form of gently sloping plateaux, such plateau-form being, as I believe, the indication of marine action upon the first formed Glacial Till.

I noticed no definite moraines, nor are glaciated rock-surfaces at all abundant, the Skiddaw Slate generally not being a good preserver of glacial markings. The best example of such that I met with was just above Port Groudale, on the north side of Banks How, where the direction of the scratches was nearly north and south. Other good cases of more or less east and west striation occur in the limestone, where exposed upon the shore, just south of both Castletown and Port St. Mary. I cannot, however, think that these last could have been produced by land-ice, but more probably they are due to current-floated ice, when the land was submerged slightly beneath its present level.

There is also a great absence of boulders on the mountain-sides; and no cases, as far as I could see, of large *foreign* boulders upon the mountain-slopes, and away from the boulder-deposits of low levels. Boulders of local greenstone and granite do, however, occur in this way, and sometimes in very anomalous positions, such as the granite blocks on the west side of South Barrule, the granite itself being on the east side, at a much lower level. Upon the east coast, especially at Port Groudale, well-rounded specimens may be gathered from the little beach of nearly all the igneous and granitic rocks common in the western and north-western portion of the Cumbrian mountain area, mixed doubtless with specimens from Scotland.

Altogether, I should be inclined to say—from a limited acquaintance with the island and its Drift phenomena—that the marks of an old land-glaciation were few as compared with those left by marine conditions acting during this period. Of local glaciers I could find little or no evidence, though on a more thorough survey some may perhaps be found. It is more than probable that the ice-sheets from Scotland and Cumbria, or from the former alone, swept over this island, glaciating it from north to south, and leaving behind much unstratified till. Then came a period of submergence, when old glacial deposits were modified, and floating-ice, during at least part of the period, transported boulders from Cumbria, and locally to and fro between different parts of the island, the shore-line being oftentimes well glaciated in the process.

At one time the island, as it now stands, must have been represented by a chain of islands separated from one another, much as the Calf is now parted from the mainland, with strong tidal currents setting through the straits. Thus the Spanish Head promontory must have been parted from the Bradda Head island, and this again from the larger tract of hilly country between Fleshwick Bay and Slieau Whallian, forming the South Barrule island; while the strait running between Douglas and Peel must have separated the southern islands from the large northern one comprehending all the northern part except the low and exclusively drift-covered extremity.

The question next arises, To what extent was the island submerged? In my Papers and Memoirs upon the Geology of the Lake District I have given reasons for thinking that that area was submerged to the extent of some 2,000 feet or more; the evidence being mainly derived from the position of various groups of boulders. Similar evidence in the Isle of Man is for the most part wanting, so far as my limited researches enable me to judge, though the presence of granite boulders upon the western slopes of S. Barrule, up to a height of nearly 1,500 feet, points rather in the same direction; for it is not easy to understand how an ice-sheet coming from the north could carry boulders in a W.S.W. direction to the other side of a mountain some 700 feet higher than the ground from which the granite blocks could be derived. On the other hand, if the island were gradually submerged to the depth of 1,500 feet or more, shore-ice might by degrees raise the blocks of granite, and they would be carried in the end to positions into which they could not possibly have been brought by an ice-sheet moving from the north.

But there is yet another fact pointing to a great submergence. There are no Alpine plants upon the mountains of the Isle of Man, no trace—according to the late Edward Forbes (quoted by Cumming in an appendix to his volume)—of that Alpine Flora which has representatives upon the English and Welsh mountain-summits, and which remains as a testimony to the geologically recent Arctic climate of our latitudes. Now this receives a full explanation if we can find reason to believe that the highest land upon the island was completely submerged after the period of maximum glaciation. If there was a submergence in the adjacent Cumbria to the extent of 2,000 feet, it is certainly not impossible that the area of the Isle of Man experienced a submergence to the same amount; and since Snae Fell is only 2,034 feet in height, this would mean the destruction of the glacial flora altogether.

It may be difficult to believe in this great oscillation of level, but if the evidence is strong in support of it, mere difficulty of belief must not stand in the way of our accepting it. It is certainly not more difficult to believe than the fact that Alpine summits 12,000 feet high, formed of marine beds of Eocene age, must have been elevated to this amount, accompanied by contortion and metamorphism of the rocks, since the close of that period. It has always seemed to me that the unwillingness to admit this great depression and re-elevation in such recent times, on the part of some geologists, arose in this case from there being so little to show for it, or, in other words, from the movement having necessarily taken place quickly or continuously, and for the most part unaccompanied by great disturbance. But surely if widespread movements of the crust are possible at all—as we know they are—we need not expect them always to take place at the same rate, or to be accompanied by similar results. It is well also to remember the strong evidence brought forward of late to show that great submergence took place at this same time over the northern part of N. America (see especially the papers by Mr. G. M. Dawson).

Physical History of the Isle of Man and Cumbria contrasted.

Contrasting now the physical history of the Isle of Man during past periods with that of the Lake District, we find that the earliest records in both areas are of the same age—that of the Skiddaw Slate; and that in both cases the deposits indicate a generally shallow sea in which muddy and sandy strata were laid down, while the still coarser material of an occasional pebble-bank points to not far distant continental land.

While this state of things was interrupted in Cumbria by an outburst of volcanic violence, sub-marine eruptions passing into sub-aerial, we have no direct evidence to show that such was the case over the present area of the Isle of Man, though it is probable that some of the finer volcanic ash was, at any rate, occasionally wafted for many miles westwards. That this area, in common with that of Cumbria, underwent elevation, accompanied by denudation, in post-Silurian and pre-Carboniferous times, is at any rate probable, and, as in Cumbria also, the early formed Carboniferous strata were deposited around a Silurian nucleus, the embryo Isle of Man. At this time, off the shores of that early Mona, submarine volcanic eruptions recurred, synchronous or approximately so with other like eruptions occurring farther northward over the present area of Scotland. There is no evidence of any such action taking place around the shores of the Cumbrian nucleus, although there are, south of Ullswater, masses of basalt which have broken into the Basement Conglomerate, and which may represent—as may also the Shap granite—abortive attempts of the Volcanic fires towards eating their way to the surface. Then in both areas we find the long unrepresented periods from Carboniferous to Glacial times, during which, after elevation at the close of or soon after the Carboniferous period, the mountain district of Cumbria and Mona's Isle were respectively fretted by the denuding forces into their present form of hill and dale, under climates varying from semi-tropic warmth to glacial cold. As the cold of our last Glacial period, so called, reached its maximum, both districts were shrouded in ice-sheets, that of Cumbria self-born, that of Mona bearing down upon it most likely from a distance. Then followed a milder time and a submergence to such an extent that in all probability Cumbria was represented by but a group of islands and Mona disappeared entirely beneath the waves. As the land in both areas once more appeared, glacial conditions returned to a considerable extent, and floating-ice laden with stones and boulders played its part in the cold drama, small bergs and floes being wafted first in one direction, then in another, as the currents changed with the varying amounts of elevated land. At length both the hilly areas of Cumbria and Mona stood up once more as of old, surrounded by a framework of low-lying land connecting the two districts, and allowing of the migration of fauna and flora from what by slight depression soon became the mainland, to the future independent Island of Man. Thus Mona is like a cast-off bud from Cumbria's group of rocky mountains.

EXPLANATION OF PLATE I.

Fig. 1. Sketch-Map of the Isle of Man.
,, 2. Sketch-plan of Volcanic Rocks at, and west of Scarlet Point.
,, 3. Conglomerate resting unconformably upon Skiddaw Slate, and the two faulted against one another. West side of Langness. The slate has been worn away leaving a natural arch of conglomerate.

II.—Eccentricity and Glacial Epochs.

By the Rev. E. Hill, M.A., F.G.S.;
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DR. CROLL'S "Climate and Time" is perhaps the most important geological work that has appeared in recent years, certainly the most valuable and original that refers to Glacial Geology. It teems with novel and instructive ideas. The part which is best known and has chiefly contributed to its celebrity is the theory, propounded and maintained in the first four chapters, of the causes of the Glacial Epoch. Though the theory met with much opposition at first, it seems now to be gradually gaining belief. Not only are Dr. Croll's views accepted by geologists, but his arguments are quoted in text-books. Now, when Science is used as a means of education, it is of high importance that the reasoning placed before the student should be sound. I propose in this article to examine Dr. Croll's description of the manner in which, according to his views, Glacial Periods have been brought about, to discuss the soundness of his reasoning, and to investigate the actions of the causes which he suggests. Some of the remarks here made are probably originally derived from an able article by Mr. S. V. Wood, jun., in the Geol. Mag. for 1876. The suggestion at the end of the paper is due to Mr. W. M. Hicks, M.A., Fellow of St. John's College.

Dr. Croll's theory, as developed in Chapter IV. of "Climate and Time," is, that a Glacial Period was a period during which the eccentricity of the earth's orbit was near its highest value, and the position of the Earth's axis such that the Pole of the hemisphere under consideration was leaning away from the sun, and in darkness at the time of the year when the earth and sun were at their greatest distance apart. In astronomical language, it happened when, during a period of maximum eccentricity, winter and summer coincided with aphelion and perihelion respectively. In support of this theory he reasons as follows. When the eccentricity is larger, the winter will be longer than it is at present, and, owing to the sun's greater distance, also colder. Thus, at the commencement of the short summer the ground will be covered with snow and ice to an extent beyond what we at present experience. The summer's heat will be unable wholly to melt this; the quantity at the beginning of the next summer will be even greater than before, and the snow or ice will continue to accumulate year by year, so that with sufficient time any quantity whatever may be reached. The summer heat will be unable to melt the winter's snow, he says,—First, by reason of the lowered temperature, lowered "by means of direct radiation" (that is, so far as I can understand, the masses of snow chill the air, and so render it incapable of melting them). Second, by reason of the reflective power of snow and ice. Third, owing to the thick fogs which are generated by the chilly masses, and shield them from the sun. Fourthly, by the deflection of ocean currents which would result from intenser trade-winds brought about by the intenser cold which would invade the pole of the hemisphere considered.

Before discussing these arguments in detail, it will be well to clear our minds from a misconception. Dr. Croll ascribes much importance to the greater length of the winter in periods when the eccentricity is large. This length, when the eccentricity had reached its highest value, might exceed its present limits by as much as forty-four days. Forty-four days more winter sounds enormous at first. Six weeks more of the severest cold, six weeks more skating and snow, would indeed be a change in climate. But this will not be the change in any temperate region. Dr. Croll is using the technical astronomical definition of winter, the time between the autumn and the spring equinoxes, the period during which the day is less than 12 hours long. This period would, no doubt, be lengthened by forty-four days. But practically in England there are hardly more than two months in which snow can resist the sun. We seldom get skating except in December or January. Six weeks additional to half the year gives a fortnight additional to two months. If two months be a fair measure of the magnitude of our present winter, the increase during maximum eccentricity would be a fortnight, which is somewhat less alarming. Further, not only practically, but theoretically, this technical definition of winter is a bad one. The only important period which it represents is the period of daylight at the Pole. If we want to divide the year into a cold half and a warm half, the equinoxes are not the proper points of division. For they do not divide the year into halves of equal length, and the amount of heat received in them is neither a mean nor a fixed amount. Although their lengths are the same, all years alike, no matter what be eccentricity or obliquity, the amount of heat received during them is not the same, for the distance of the sun differs with differing eccentricities. The most natural way of fixing the division for any place would be to calculate the mean amount of heat received per day on the average of the whole year. Then let all the days during which the heat received from the sun exceeded this average diurnal amount be called Summer, and the period during which the daily heat fell short of this average be Winter. This would give a length for Summer, subject to variation by change of eccentricity, to an extent greatest at the pole, diminishing towards the equator, and thus would more nearly represent the true state of the case.

There is not much importance in this difference of definition. Indeed, in dealing with our subject it is better to use neither. The simplest and clearest division is that into halves of equal length. Dr. Croll divides his year into two parts, in which the amounts of heat received are equal, but the times unequal. We shall find it more useful to take two equal times in which the amounts of heat received will be different. The six months nearest to the Winter Solstice we will call Winter, and those nearest to the Summer Solstice, Summer. Our summer will be, roughly, from April to September; our winter, October to March. All the hottest days will be in one half, all the coldest in the other. The line between summer and winter is then so drawn as to divide the heat received most unequally. We will neglect for the present (as Dr. Croll does) the small difference made by change of eccentricity in the whole amount of heat annually received from the sun, and consider that total unalterable. If the eccentricity increase, the earth draws nearer the sun in the one half the year, is further from him in the other half. If midsummer coincide with perihelion, the increase will cause more heat to be received by the hemisphere in the summer half of the year, and less heat in the winter half. But since the total remains the same, the excess in one half is equal to the defect in the other. The amount of heat received in the year is unaltered; it is only differently distributed. Dr. Croll's theorem, therefore, may be stated thus,—A Glacial period may be produced by a different distribution of the fixed amount of heat received annually, and the most favourable distribution is that by which as much as possible is concentrated into one-half the year.

We will proceed to examine this theorem, and the arguments which are adduced as a demonstration. We must bear in mind that the Glacial period to be accounted for is not simply a cold winter, or a succession of such, but a period during which ice and snow accumulated to a vast mass, permanently covering our country during summer as well as winter: a time when a glacier 1000 feet thick lay in the pass of Llanberis, and the ice-sheet from Scandinavia (according to Dr. Croll) ground down the Orkneys and the Hebrides. Every one admits that these vast amounts could only arise by successive increase during long periods of years. Dr. Croll's explanation is that, during periods of high eccentricity, such quantities of snow and ice will be formed in the long severe winter, as the short summer will be unable to melt. I always feel bewildered at his beginning with the winter. Has not summer as much right to be considered? Why not say that in the intense heat of summer more polar ice will be melted than now? We might exactly reverse his argument. Yes, says Dr. Croll, but the winter is longer. But I must rejoin, what have short and long to do with the question? The quantities of heat are unaltered, he admits. Quantities of heat, not lengths of time, are what we ought to look at. To melt a mass of ice, a definite quantity of heat must be supplied; to form the same mass, an equal quantity must be subtracted. The amount of heat received annually will not be less than at present; no reason is given why the amount given off should increase. If snow is to begin to accumulate, more must be formed than is melted; then either more heat must be lost annually, or else less received than is now the case. But how will increased eccentricity be able to bring about either of these effects?

The matter will be made more clear by dividing the year into two equal halves, as I described above. We have no reason to suppose that at present in the Northern Hemisphere more snow or ice is anywhere formed in winter than is melted in the summer. With greater eccentricity less heat than now would be received in winter, but exactly as much more in summer. More snow would therefore be formed in the one half of the year, but exactly as much more be melted in the other half. The colder winter and the warmer summer would exactly neutralize each other's effects, and. on the average of years, no accumulation could begin. *Primâ facie* therefore high eccentricity will not account for Glacial periods.

Dr. Croll does not deny that this is *primâ facie* true, but he alleges that secondary actions will prevent the summer from thus neutralizing the winter. Here come in the four causes which we have already quoted as the bases of his theory. It may be thought that what has been said renders consideration needless. Since to set them at work, an accumulation of snow must have commenced, and since so long as no accumulation can begin they cannot operate, at least to any greater degree than at present, it should follow that any discussion of their operation is superfluous. This appears to be Mr. S. V. Wood's view, when he objects to the reasoning as a reasoning in a circle. But the objection is not altogether well founded. I think it can hardly be doubted, that though the summer would melt more ice than is now melted, the winter would form more than is now formed. At midsummer there might be less than there now is, but at midwinter more. We have as yet no *primâ facie* reason for yearly increasing accumulation, but we have *primâ facie* reason to think that the extreme cold of winter would produce quantities of snow in excess of what we now experience, even after allowing for the quantities melted by the extreme heat of the previous summer. And this greater extension of midwinter snow is exactly what Dr. Croll requires for his causes. It is the force necessary to set his machinery in motion. The question now is, will the machinery work?

The First alleged reason is the cold produced by masses of ice and snow. If this means that the snow will not be melted easily, because it cools the air, there is a self-contradiction. Snow can only cool the air by abstracting heat from it, and if snow takes up heat, the heat is spent in melting it. As for what is said about cold rendering air diathermanous, so much the better for the melting. If the sun's rays can readily pass through the air, they will the more readily reach the snow which they have to melt. These paragraphs are not worthy of the book.

The Second cause alleged is that snow crystals tend to reflect the heat which ought to spend itself in melting them. This is perfectly true, an entirely valid argument, a real cause acting in the required direction. The matter is not altogether obvious. Suppose that at present over a given region snow is formed in one half the year and just entirely melted in the other half. Then, if owing to some change of circumstances twice as much snow is formed in the first half, but twice as much heat received in the second, then the snow would be entirely melted as before, and no accumulation would begin. But the case we are dealing with is different. At prèsent, a certain amount of heat is lost during the year, but just as much received. Part of that lost is radiated off into space by water or vapour freezing into ice and snow. An equal part of that received is used up in melting this snow, and a certain additional quantity, a fixed fraction of the above, is wasted by reflexion from the snow into space. Now, suppose that by some change in the distribution of the heat-supply, less heat is received in the cold season. Then more of the heat lost is radiated off in the formation of more snow. As much more heat is received during the warm season, just sufficient to melt the additional snow if wholly effective for that purpose. But since there is now more snow than before, more heat is reflected away, and therefore less than the whole of the additional heat of the summer is available for melting. Thus less than the whole of the snow formed in the winter will be melted in the summer, or, at all events, less heat will remain available to warm the earth in the warm season, and accumulation of snow or of cold will begin.

But while this cause alleged by Dr. Croll is theoretically correct, what practical amount of effect it may have is quite unknown. I am not acquainted with any researches into the proportions of heat reflected and absorbed by ice and snow. Experiments are much to be desired. The rapidity with which dark objects sink into snow, and small stones into glacier-ice, shows that ice and snow must reflect much heat. On the other hand, snow and ice, like other good reflectors, are bad radiators. They will not cool so fast and far—they will not radiate away so much heat—as the ground would if left bare. Snow again is known to be a good non-conductor of heat: the young corn has been saved by it from many a frost, and the Esquimaux in their snow-hut may perspire with warmth. The coating of snow thus tends to diminish the winter's loss of heat in a manner precisely answering to the way in which it diminishes the summer's effect in melting. The actions of non-conduction and bad radiation are precisely contrary to that of reflexion, and for anything we know to the contrary may precisely balance it.

Great stress is laid by Dr. Croll on the Third cause, the effect produced by clouds and fogs in lowering temperature. I cannot think they have any effect of the kind. Mr. S. V. Wood's objection, that vapours give out in condensation as much heat as they absorbed in formation, seems to me to be fatal. Dr. Croll brings forward a mass of testimony which proves that many cold and icy regions are subject to thick fogs. But it proves no more. None of the evidence shows whether the fogs produce the cold, or the cold gives rise to the fogs. The latter is as possible. We do not attribute the cold of mountain summits to the clouds which so often settle on the peaks. Let us consider the effect on temperature of the formation and dissipation of a cloud or a fog. We know that not only is heat being constantly poured on to the earth; it is also constantly streaming off from it into space. We suppose that at present the mean annual temperature of places is not on the whole changing. Therefore, on the average of years the total annual receipt of heat must balance the total annual loss. Expenditure must equal income if there be neither debt nor saving. Suppose, then, winter ended, spring beginning, and the sun pouring heat upon the earth. The heat converts snow and ice into water, water into vapour, but this is chilled by the neighbouring snow into mist and fog, which intercept the sun's genial beams, retarding their effect on the frozen mass. This is Dr.

Croll's picture. But there is a companion to it, which he seems not to have looked at. Suppose winter coming on. The sun is sending little heat. The earth is steadily radiating heat away. Its temperature falls. The vapour in the air is condensed into fog, and the fog checks radiation from the earth, causing it to cool more slowly. Every gardener in fear for his plants, every skater longing for a frost, knows that severe cold and a cloudy sky are almost incompatible. Fogs retain at least as much heat as they exclude.

If then clouds and mists and fogs are as capable of checking heat radiated from the ground as of intercepting heat received from the sun, and if the amount received from the sun does not exceed that radiated from the ground, it is impossible that clouds or fogs can tend to lower the mean annual temperature. It may, perhaps, be thought that a stratum of clouds high above the ground will receive, absorb, and retain the heat coming both from earth and sun. True, but if they receive heat and are warmed, they can and will radiate heat off, both outwards and inwards. Only part of the earth-radiation intercepted is restored to the earth, but part of the sun-heat intercepted is passed on to the ground. However, when heat is intercepted by mist, its main effect is to convert the mist into transparent vapour, giving freer passage to radiations. In the formation of the cloud, heat is given off from the vapour; in its reconversion into vapour the same amount must be absorbed. Clouds and fogs cannot do the work which Dr. Croll requires of them. If high eccentricity is to produce a Glacial epoch, they will lend it no aid.

One action, however, they have; an important one; to which Dr. Croll appeals elsewhere (cf. pp. 36, 38, 90 [4]), though here he seems to neglect it. The heat received from the sun, and that radiated from the earth, though equal in quantity, are not identical in quality. The former has greater power of penetration. More of it will pass through an interposing medium. The intense sun rays will penetrate fogs which would almost wholly stop the feeble earth-heat. Fogs, therefore, do not diminish income and expenditure of heat alike. They diminish expenditure more than income, and on the whole average of the year actually must tend to increase the temperature.

The Fourth, the only remaining cause, is the one on which Dr. Croll appears now mainly to rely (cf. for instance, GEOL. MAG. 1878, p. 397; 1879, p. 480). Perhaps the most fascinating part of Dr. Croll's whole book is that in which he argues that Polar accumulations of ice will intensify the North-east Trade-winds, thereby drive the Equatorial currents further to the south, diminish the part of them which as the Gulf Stream passes into the Atlantic, and so perpetuate and intensify the previously increased Polar cold. Nothing more original and remarkable occurs in this most remarkable and original book. But will the action take place?

Let us neglect the disputes concerning the influence of the Gulf Stream on climates, and the dependence of currents on winds. Let us neglect also the (important) possibility that the greater speed which the current would possess might compensate for its decreased volume. Let us consider the whole year's cycle of action. Suppose the earth's present orbit to be suddenly changed into the necessary shape for maximum eccentricity and winter in aphelion. During the winter half of the year there would be far more cold in Northern regions than now, and a greater difference between the temperatures of Equator and the Pole.[1] The trade-winds are supposed to depend for their intensity on this difference. They would be intensified and act as Dr. Croll requires. But during the summer half of the year there would be as much more heat in Arctic latitudes than now, and a less difference between Equator and Pole. The trade-winds would be feebler to a corresponding degree. The Equatorial current would not lie so far south as it does. More of it would pass into the Carribean sea, and the Gulf Stream would carry more heat into the Atlantic, thus ameliorating the climates of its coasts. Summer effects and winter effects precisely balance, and equilibrium is undisturbed. Nor is the slightest difference made if any part of the cold be locked up in the form of ice. This ice in melting absorbs heat and lowers or retards the rise of temperature, but in forming it parts with exactly the same amount, and correspondingly raises the temperature of the air or retards its fall.

We may put the argument into a compacter form. No matter the way in which heat may produce air currents, equal quantities of heat must produce equal quantities of work, and therefore equal effects on currents. Change of eccentricity does not (appreciably) alter the total amounts of heat received at any place during a whole year, though it may alter the distribution through the year. Thus it cannot alter the whole effect on currents, though they may be sometimes accelerated, sometimes retarded.

We have thus gone through Dr. Croll's four causes, or rather modes of action, whereby high eccentricity might, as he maintains, produce a Glacial Period. The first is non-existent. The second may possibly have an effect. The third at best cannot work at all, and almost certainly works in the wrong direction. The fourth might work if set going, but has no power of starting itself. It could, perhaps, be put in motion by aid of the second. But against this must be set, not only the probability of a counteraction by augmented velocity and the opposite effect of the third, but also the real though small increase of total annual heat received during increase of eccentricity. This we have hitherto neglected, but it exists, and must have its effect, which must be to diminish permanent snow. Dr. Croll dismisses it without discussion (note, p. 58), but, unlike the others, it indisputably acts.

It should be noticed that though for convenience we have assumed that at the present epoch the Arctic snow cap is neither increasing nor decreasing, yet this assumption is entirely unnecessary. The above investigations show that, whatever be the present state of the case, change in eccentricity has not been proved by Dr. Croll to have any power of changing that state.

[1] Would this happen? The increased distance of the sun would affect Equator as well as Pole.

Our verdict, then, on Dr. Croll's celebrated theory, must still be "Not Proven." It would be sad indeed to send to the waste-paper basket those splendid tables of varying eccentricities. It would go to the heart of a mathematician to dismiss the question from the dominion of mathematics, and to abandon hope of calculating an era for a chronology. I cannot bring myself to this. I think that Dr. Croll has attacked the problem in a right manner, and that a solution will be found based on gain and loss of heat. I am even inclined to believe his opinion to be the true one, and that variations in eccentricity did bring about the Glacial Period. Extremes of heat and cold would tend to produce atmospheric disturbances, and these seem practically inimical to warmth. Extremes might also destroy vegetation and so affect climates for the worse.

There is, however, another mode of action, which, so far as I know, has not before been suggested. The earth loses the heat which it receives mainly or entirely by radiation; we have not yet considered the laws of this radiation. The amount increases as the temperature rises, decreases as it falls. If these changes were proportional, there would be nothing to need consideration. But they are not proportional. The amount of radiation increases faster than the temperature. The heat sent off in summer is more than in proper proportion to that sent off during winter. Suppose a uniform supply of heat. Then the earth would reach a steady temperature, such that there would be a uniform emission of heat equal to the uniform supply. Now, change this uniform supply into a supply so fluctuating, that the total annual receipt of heat is unchanged. The temperature will fluctuate, and consequently the emission of heat. The excess above the mean of the heat emitted during the warm part of the year will exceed the deficiency below the mean of the emission during the cold part. The storage of heat during the summer will therefore fall short of the consumption during the winter, and the average temperature must fall. Or, putting the action in a different aspect, as the supply of heat to a body is increased, the temperature increases in a continually diminishing ratio. Thus any increase in the supply of heat would not increase the temperature quite so much as an equal decrease in the supply would decrease the temperature. Accordingly fluctuations in the rate of supply, even when not affecting the average amount supplied, must diminish the average temperature. The Equator receives its heat uniformly compared to the Poles, which are subjected to extreme vicissitudes. Hence the Equatorial mean temperature ought to exceed that of the Poles, even if the total amount received were the same for both. And in the same way increase of eccentricity, aggravating the extremes of temperature, must produce a diminution in the mean. What will be the extent of the diminution is a problem which deserves attention. So far as I have yet been able to form an estimate, it is appreciable, but not large.

This, then, is the position in which the question at present stands. Increase of eccentricity acts in the direction of a Glacial period, probably through increased reflexion of heat by snow and ice, almost certainly through diminished mean temperature resulting from increase of extremes: but some minor causes act in the opposite direction, and as yet nothing is known of quantitative effects. For the present, therefore, corroborative evidence may fairly be adduced, as is done by Dr. Croll in the cases of the present Antarctic Ice-cap and the supposed Inter-glacial periods. The discussion of these corroborations is beyond the scope of the present article.

III.—On some Fossil Bird-Remains from the Siwalik Hills in the British Museum.

By William Davies, F.G.S.,
of the Geological Department.

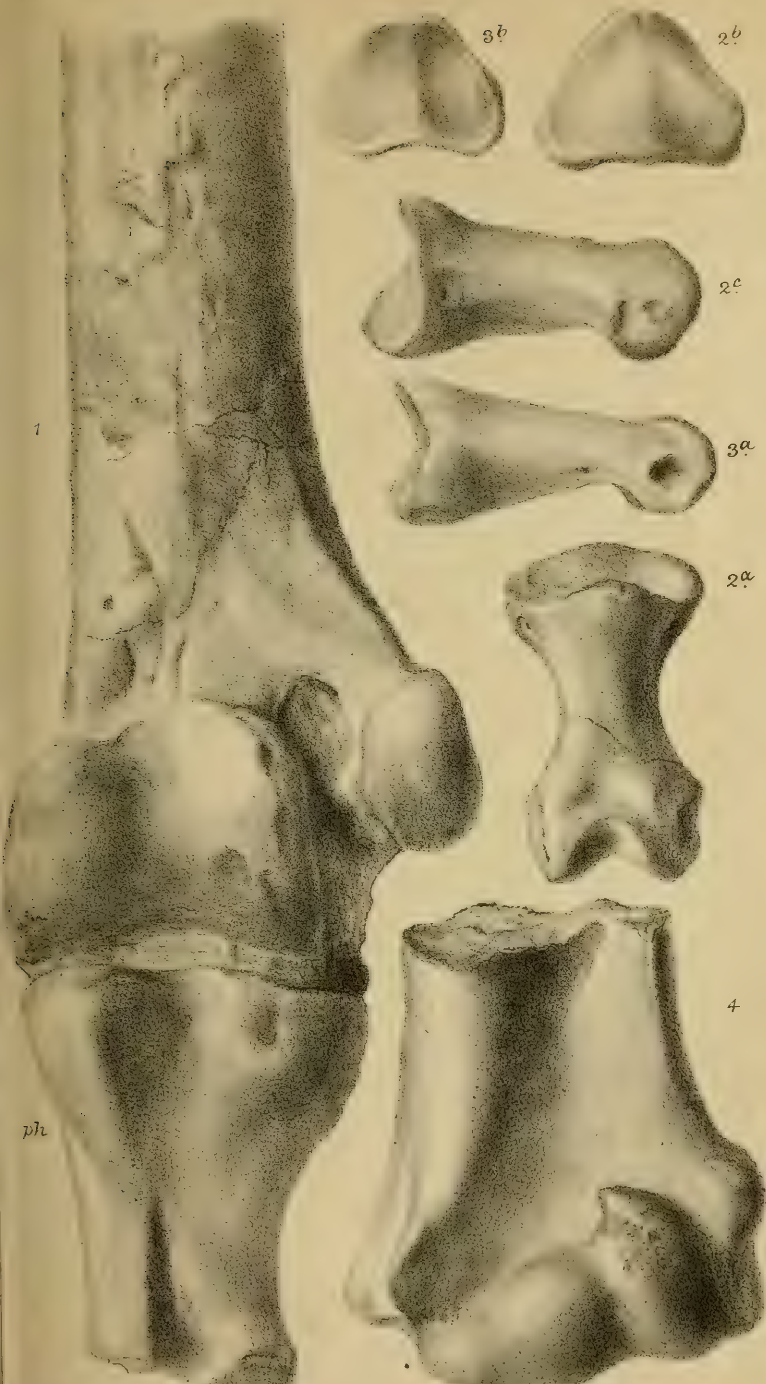
(PLATE II.)

THE first part of the "Records of the Geological Survey of India" for 1879 contains some interesting notes by Mr. R. Lydekker, B.A., descriptive of a "few fragmentary bird-remains" recently obtained from the Tertiary deposits of the Siwaliks, and preserved in the Geological Museum at Calcutta. The subjects of most interest alluded to in this memoir are some bones referred to *Dromæus*, by Mr. Lydekker, and his remarks thereon, and upon some bones of kindred birds which form part of the extensive series of vertebrate remains collected in the same range of hills by the late Colonel Sir Proby T. Cautley, then Captain in the Bengal Artillery, and presented by him to the National Collection.[1]

These special fragments preserved in the above-named Museums are of great palæontological interest, for assuming Mr. Lydekker's identification of the bones in the Indian Museum to be correct, the fact is fully established, that in the Upper Miocene or Lower Pliocene period, there lived contemporaneously in India two distinct forms of Struthioid birds, whose geographical habitats are, in the present day, widely separated: namely, the Ostrich in Africa and the Emu in Australia. The evidence as regards the Ostrich rests upon specimens in the National Collection which have never been described, and being but little known, a short description might usefully supplement, and also correct some misapprehensions regarding them contained in Mr. Lydekker's notes.

Commenting upon the rarity of avian remains in the Tertiaries of the Siwaliks, he remarks: "Some of these bones were collected by Dr. Falconer, and were deposited by him in the British Museum." This is an error. They were collected and presented, as stated, by Col. Sir P. T. Cautley. Mr. Lydekker adds, "Figures being given of them

[1] Most of these specimens were drawn on stone for the "Fauna Antiqua Sivalensis" of Falconer and Cautley; being one of a series of eighteen plates which were never printed for publication, and of which only one impression of each—a proof—has been preserved; the drawings having, during Dr. Falconer's lengthened absence in India, been erased from the stones. These impressions are deposited in the Geological Department of the British Museum; and explanations of the figures on each plate, which are respectively lettered A to R, are published in Dr. Falconer's "Palæontological Memoirs" (vol. i. pp. 538—554), edited by the late Charles Murchison, M.D., F.R.S.



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

Fossil Bird Bones.

on Plate R. of the unpublished plates of the 'Fauna Antiqua Sivalensis' on the evidence of these bones, M. A. Milne-Edwards[1] established two species of extinct Siwalik birds, namely, *Struthio asiaticus* and *Argala Falconeri*" (p. 52). Further on he observes: "With regard to *Struthio asiaticus* of M. Milne-Edwards, it appears that this species was formed on the evidence of the phalange. and of the distal extremity of the tibio-tarsus, which are represented in figs. 2 and 15 of the above-quoted plate;" and again, "I am rather at a loss to discover how M. Milne-Edwards determined that his Siwalik ostrich had but two toes, because, as I have said, the only Struthioid bones figured in the 'Fauna Antiqua Sivalensis' are the distal extremity of the tibio-tarsus and a phalange" (p. 53). The species was, however, not founded upon these two bones, as Mr. Lydekker supposes; for in a small collection of vertebrate remains obtained from the same locality, and presented to the British Museum, by the late Major Colvin, there is a distal end of a tarso-metatarsal of *a two-toed bird*, with the proximal half of the first phalange of the third toe in its natural position (Pl. II. Fig. 1, *ph.*); and this, there can be no doubt, is the specimen which Prof. Alphonse Milne-Edwards refers to as the evidence for his *Struthio asiaticus*. Yet his note relating to it, which we here reproduce, is so short and indefinite, as to justify Mr. Lydekker's conclusion.

Milne-Edwards writes (*op. cit.* tom. ii. p. 587):—

"L'une des espèces les plus remarquables appartenait au groupe des Brévipennes et se rapprochait beaucoup de l'Autruche d'Afrique par la conformation de son pied, qui ne portait que deux doigts; mais elle était de plus petite taille que cette dernière: on pourrait, pour l'en distinguer, la nommer *Struthio asiaticus*."

This unique and important fragment is associated in the matrix with a series of twelve cervical vertebræ, and also with the bones of the wing, of probably the same bird; I say probably, because, occasionally in the Siwalik deposits, bones of more than one species of animal are found in juxtaposition, as in this very group, in which an incisor tooth and an atlas vertebra of a small ruminant are in contact with, and cemented by, the matrix inclosing the avian vertebræ and metatarsal.

The result of a careful comparison of the tarso-metatarsal and phalange, with the same bones of an adult and large African Ostrich (356 a), in the British Museum, is, that as regards form and size they are indistinguishable; although M. Alphonse Milne-Edwards supposed the fossil to have been inferior in size to the recent bird, and hence suggested a new specific name; but if we eliminate the conditions of occurrence and locality, the fragment possesses in itself no distinctive character by which it could be separated from the existing African Ostrich. And the annexed measurements, in inches and tenths, of the fossil and recent bones, will show how closely they assimilate in size.

[1] Oiseaux fossiles de la France, tom. i. p. 449, tom. ii. p. 587.

	Fossil. Siwalik.	Recent. African.
Extreme length of fragment of tarso-metatarsal, exclusive of phalange ...	5·8	...
Greatest transverse diameter of the trochlea ...	2·4	2·4
Transverse diameter of third trochlea ...	1·6	1·58
Antero-posterior diameter of ditto ...	1·7	1·7
Transverse diameter of outer trochlea ...	0·7	0·7
Antero-posterior ditto ...	1·05	1·1
Transverse diameter, proximal end of phalange ...	1·65	1·7
Vertical ditto ...	1·65	1·75

The fossil phalange is a little abraded, which will account for the difference in these measurements.

The avian vertebræ associated with the preceding are twelve in number, ten of which form a consecutive series; of these, the first and the last are represented by little more than their respective approximating articular ends, the others being all more or less perfect as regards the centra; but unfortunately the confluent processes which form the vertebral canal, and also the styliform pleurapophyses, are mutilated in a greater or less degree in all. Each vertebra is closely articulated to that which precedes and follows it by the articulating surface of the centra and of the zygapophyses; and the series is bent back so as almost to describe a circle; this has been accomplished without any apparent detachment of the centra at their articular junctions, but mainly by forcing the zygapophysial facets beyond their natural boundaries, and this is shown by the slight addition that the curve makes to the length, in the aggregate measurement of the series.

Five of these vertebræ are figured, of reduced size, upon the aforementioned unpublished plate R (figs. 1, 1*a*) of the "Fauna Antiqua Sivalensis;" and represent respectively the 3rd to the 7th of the fossil series, but of which only the posterior and anterior halves of the 3rd and 7th are there delineated. By measurement and by comparison with the bones of the neck of the same skeleton of the African Ostrich (356a, B.M.), I believe the conjoined fossil vertebræ to represent the 5th to the 14th inclusive; and therefore representing the entire middle portion of the neck: the normal number of cervicals in the Ostrich being 18. The antero-posterior dimensions of the respective centra of the fossil series, which with one or two exceptions can be measured very accurately, agree with those having the same numerical position in the neck of the recent bird; and they each increase in length in the same ratio as they recede from the head.

The five vertebræ figured upon the unpublished plate R represent respectively the 7th to the 11th in the natural series, and I select one of these, the 8th, of which a view is there given (fig. 1*a*) of the inferior surface of the centrum, as a good example for measurement:—

	Fossil.	Recent.
Length of centrum along median line...	2·25	2·25
Anterior transverse diameter of vertebra over vertebral canal	1·2	1·15
Posterior transverse diameter of centrum, inferior surface ...	0·7	0·7
Vertical diameter from summit of neural spine ...	1·05	1·0

I also annex measurements of the 13th vertebra of the normal cervical series :—

	Fossil.	Recent.
Length of centrum along median line	2·62 ...	2·68
Anterior transverse diameter over vertebral canal	1·85 ...	1·47
Posterior transverse diameter of centrum	0·67 ...	0·6
Vertical diameter from summit of neural spine	1·4 ...	1·15
The aggregate lengths of eight consecutive fossil vertebræ measured along the outer curve	19·5 ...	
The corresponding eight recent vertebræ placed in the same curved position measured...		20·0
The same vertebræ placed in a straight line		19·0

The above measurements corroborate the evidence adduced from the leg-bones that the Siwalik Ostrich stood as high as its African congener; but the greater vertical depth and anterior transverse diameter of the cervical vertebræ indicate a bird of robuster proportions as regards the neck.[1]

The wing-bones, consisting of portions of the carpal ends of the ulna and radius, metacarpus and phalange, are all, with the exception of the metacarpus, fragmentary and mutilated, and only recognized by their relative positions in regard to the metacarpus. This part of the wing is sufficiently complete for identification, the most perfect element being the middle, or third, metacarpal of the pentadactyle hand, and it shows the short second metacarpal anchylosed to it; the outer, or fourth, metacarpal has the curve, characteristic of this bone in the Ostrich; it is also much stouter, relatively to the third metacarpal, than are the same bones to each other in the recent bird.

The length of the third metacarpal in the fossil is 3·6 inches, and in the recent skeleton 3·7, the proximal end of the fossil being imperfect.

The next most important fragment is the distal extremity of the tibio-tarsus afore-mentioned. It forms part of the Cautley collection, and is represented on the already quoted unpublished pl. R. (figs. 2, 2*a*, *b*, *c*, *d*); and, although unrecorded, we may assume that its affinity was known or suspected by Dr. Falconer, from his placing in conjunction with the figures of the fossil a figure of the corresponding portion of the tibia of a recent Ostrich (fig. 6). Unfortunately the fossil is imperfectly preserved, the sharp edges of the condyles being much abraded, and this defect not being clearly shown in the engraving, gives a somewhat erroneous impression as regards its original form. Nevertheless, it has the form and possesses all the characters of that portion of the shin-bone of the recent skeleton (356a, Brit. Mus. Coll.) with which it has been

[1] These vertebræ were originally assigned by the finder to the "Swan"; this name being written on one of the series; and in a small pamphlet, descriptive of Siwalik fossils, entitled, "Memoirs by Major W. E. Baker, Bengal Engineers, on the Fossil Remains, presented by himself and Colonel Colvin, C.B., to the Museum of Natural History at Ludlow" (Ludlow, 1850), it is stated that "the remains of birds have been found in the Siwalik strata, but they are of rare occurrence, and consist of bones of grallæ or waders, and of a large kind of swan." This, there can be no doubt, refers to the specimen above described.

compared. The commencement of the condylar ridges, the shape of the condyle, the anterior depression, with the condylar tuberosity which it contains, are alike in each, and the annexed measurements of the more perfect parts of the fossil, and of the corresponding portion of the recent bone, exhibit the same relative proportions, and prove it to have belonged to a bird as large, if not actually to the same individual, as the preceding fragments.

	Fossil.	Recent.
Length of fragment	7·0	...
Medial antero-posterior diameter of condyle	1·95	2·0
Anterior transverse diameter at the lateral condylar depressions ...	2·6	2·75
Antero-posterior diameter of shaft above the condylar tuberosity ...	1·2	1·12
Transverse diameter at ditto	1·8	2·0
Circumference of shaft at $4\frac{1}{2}$ inches from the distal extremity ...	4·6	4·6

At the fractured end of the fossil is seen the medullary cavity, its diameter being 0·8 of an inch, the bone having a thickness of 0·3.

As the fragments of fossil bones above described certainly belong to the genus *Struthio*, they establish the fact, so far as our present knowledge extends, that the Ostrich had its early home in Asia, its fossil remains not having hitherto been found elsewhere; also, that as regards size, the ancient bird was not inferior to its modern African congener, and in respect to the form of the bones of the limbs is indistinguishable from it. This intimate resemblance tends to the inference, if not to the assurance, that the African Ostrich is a direct descendant, perhaps slightly modified, as regards the cervical vertebræ, of the older Asiatic bird, which, at some remote period, impelled by circumstances, migrated from its original home to its present habitat. And, whatever the physical changes that necessitated the migration, it was not accomplished alone; for the Giraffe, now confined exclusively to the African continent, had also an Asiatic origin, and has left its remains, associated with those of the Ostrich, in the same Indian deposits. Referring to the fossil Giraffe, Dr. Falconer observes that the "teeth come so near those of the existing African species in size and form as to be indistinguishable."[1] And with regard to the existing African mammalia, Mr. Wallace, commenting upon the former junction of Africa with Asia, says that "all over Africa, but more especially in the east, we have abundance of large ungulates and felines, antelopes, giraffes, buffaloes, elephants, and rhinoceroses, with lions, leopards, and hyænas, all of types now or recently found in India."[2] He elsewhere observes that the migration was "apparently effected by the way of Syria and the shores of the Red Sea," and that, "by this route the old south Palæarctic fauna, indicated by the fossils of Pikermi (Greece), and the Siwalik Hills, poured into Africa" (p. 288).

The phalange referred to by Mr. Lydekker, and which is represented on the unpublished plate R (figs. 15, 15*a*, *b*, *c*, *d*), is an entire second phalanx of the middle toe of a tridactyle Struthious bird, distinct from either the Emeu or Cassowary; though approaching nearer to the latter than to the former, it possesses distinctive

[1] Palæontological Memoirs, vol. i. p. 26.
[2] Geographical Distribution of Animals, vol. i. p. 286.

characters, which cannot be referred to sexual or individual variation of either of the above-named birds. A glance at the representations of the fossil (Pl. II. Fig. 2 *a*, *b*, *c*) and corresponding phalanx (Pl. II. Fig. 3 *a*, *b*) of the Cassowary (585*b*, Brit. Mus. Coll.) shows the essential points of difference. The fossil is much stouter in proportion, the length being nearly the same in each, nor does it taper so rapidly forward; the proximal end is vertically deeper and more regularly triangular in outline, the inferior marginal border is convex, whilst in the Cassowary it is slightly concave; the lower half of the articular surface is also broadly convex, with shallow condylar depressions on either side, but exhibits no trace of an intercondylar ridge,[1] whereas in the Cassowary a narrow vertical median ridge is well defined between two broad and comparatively deep depressions which receive the distal condyles of the first phalange. In the fossil the anterior or anconal surface of the phalange rises rather abruptly near the proximal end, the middle portion of the bone being slightly depressed; the anconal surface of the phalange of the Cassowary forms a nearly straight line. The distal articular groove is deeper and relatively broader, the condyles rising higher and being less rounded; the pre-condylar depression is also deeper and broader in the fossil than in the recent bone.

These differences impart to the fossil a distinctive osteological character, and a special palæontological interest, inasmuch that it is evidence—so far as a digital bone of the pes can be accepted as evidence—of a third species of Struthioid bird, genus undetermined, having been contemporaneous with the Ostrich and Emeu in the ancient plains of India.

The following measurements will show the relative proportions of the fossil and recent bone:—

	Fossil.	Cassowary.
Length of phalanx	1·68 ...	1·55
Transverse diameter, proximal end	1·05 ...	0·98
Vertical diameter	0·8 ...	0·68
Transverse diameter, distal end	0·85 ...	0·74
Vertical diameter, between condyles	0·48 ...	0·36
Smallest circumference of shaft	1·8 ...	1·57

Argala Falconeri, A. M.-Edw.

Professor Alphonse Milne-Edwards has described some fragmentary remains of a gigantic Crane preserved in the Cautley Collection in the British Museum, under the above designation.[2] They comprise two distal extremities of tibio-tarsi, and a proximal and distal end of the tarso-metatarsus. The descriptions, with measurements of each, are brief, and unaccompanied by figures. They are, however, represented by several views of each bone of the size of nature upon the unpublished plate R. (figs, 3, 5, 9 and 11) of the "Fauna Antiqua Sivalensis."

There are, besides the above, two other fragments in the same

[1] The figure on the unpublished plate is not a faithful representation of the proximal articular surface.

[2] *Op. cit.* tom. ii. p. 449.

collection, also figured upon the same plate, which appertain without doubt to the same species of Crane, but are unnoticed by Prof. Milne-Edwards.

The first fragment consists of little more than the proximal third of the first phalange of the wing, and is faithfully represented of the natural size on pl. R. (figs. 8, 8*a*, *b*, *c*). The articular surface, although not quite perfect, coincides in form with that portion of the phalange of a recent bird, and with regard to size the antero-posterior diameter is 0·5, that of the recent bone being 0·42; the articular surface of the fossil is imperfect in the transverse direction. The lateral lamelliform expansion rises more abruptly than in the recent bone, but this is the only difference that I can detect.

A second fragment, which is also figured upon the above-quoted plate (figs. 4, 4*a*, *b*), is the distal extremity of a left femur; it is somewhat mutilated, and is broken below the commencement of the condylar ridges, and therefore represents little more than the articular end. Compared with the femur of a skeleton of *Argala indica* (397a) in the British Museum, I again fail to detect any specific character—size always excepted—by which the fossil can be distinguished from the recent bone, unless it be that the anterior condylar groove in the fossil appears to be relatively a little deeper and narrower, a point of very slight importance. As regards size, the transverse diameter of the articular surfaces of the condyles in the fossil and recent bones, which measure respectively 1·77 and 1·48, will indicate the degree in which they differ.

Another important fragment, which originally belonged to the late Dr. Falconer, and has only recently been acquired for the National Collection by the liberality of his brother, Charles Falconer, Esq., F.G.S. (since deceased), is the distal extremity of a left humerus (Pl. II. Fig. 4). It is in good condition, the condyles being perfect, and the anconal surface of the bone beautifully preserved; a portion of the palmar surface is destroyed. And, as in the previously described fragments, it is also indistinguishable from the corresponding portion of the humerus of the great Indian Crane; so that, with the exception of size, of which I append comparative measurements, it possesses no distinctive characters for special description.

	Fossil.	Recent.
Length of fragment	2·5	...
Transverse diameter at condylar tuberosities	2·3	... 2·1
Ditto, of condyles	1·75	... 1·5
Antero-posterior diameter of base of shaft, radial side	0·9	... 0·7

All the above-mentioned fragments of bones, representing various portions of the skeleton, and probably of as many individuals, being in accord as regards their relative proportions, tend to the conclusion that the remote ancestors of the existing Adjutant Crane surpassed it in size; yet there is in the National Collection a lower extremity of a tibio-tarsus, no larger than is that of the recent skeleton with which the other fragments have been compared. Mr. Lydekker himself states, that, of three bones of *Argala Falconeri*, in the Indian Museum, two are of "exactly the same size," and the "third is slightly smaller" than in the living Adjutant. This inequality in size may foreshadow another palæontological species, to be perhaps hereafter determined, when other and more perfect portions of skeletons shall have been obtained; at present we can only refer it either to sexual disparity, or to great variation in individual growth. The intimate resemblance of the fossil and recent bird-bones is a character common to other classes of Siwalik vertebrate fossils, of which representatives are still living in India, and has been a subject of comment by various writers. Dr. Falconer, remarking upon the abundance and variety of form of the reptilian remains, says, "*Leptorhynchus gangeticus* and *Emys tectum* are indistinguishable from existing species," and, "in several instances the fossil forms make the closest approach to species now living in India. This is also the case with several of the Carnivora."[1]

The only reference to birds by the above eminent authority upon Siwalik fossils in the work above quoted is the following short paragraph:—"Among the Siwalik fossils there are also the remains of several species of *Birds*, including *Grallæ*, greatly surpassing in size the gigantic crane of Bengal (*Ciconia Argala*)"—*op. cit.* p. 23.

With regard to the proximal end of a small tarso-metatarsal, which M. A. Milne-Edwards considered, though with doubt, and after hasty examination, to have belonged to a bird allied to the existing Tropic Bird (*Phæton phœnicurus*, Gmel.), but about one-third larger, Mr. Lydekker observes: "It seems incredible that a bird of that essentially oceanic genus could have lived in the land-locked Siwalik country. The difficulty may perhaps be got over by calling in question the authenticity of the locality of the bone, of which there seems no certain history." This ready, though not scientific method of disposing of a palæontological difficulty, will, happily, in this instance not apply: the history and locality of the bone in question being well authenticated, as it forms part of the Cautley collection, and is moreover figured upon the oft-quoted unpublished plate R (figs. 13, 13*a*, *b*), upon which plate all the fossils figured are unquestionably from the Siwaliks. The following quotation will also show that Milne-Edwards carefully avoided committing himself to any positive assertion as to the genus or the affinity of the fossil. He says: "Mais je ne propose cette détermination qu'avec une grande réserve, car je n'ai étudié ce fossile que très-rapidement, et il serait necessaire de la soumettre à un examen comparatif approfondi."[2]

The fragment does not agree with Milne-Edwards's figure of the tarso-metatarsal of *Phæton phœnicurus* (*op. cit.* pl. 32, figs. 6–10), nor yet with the recent bone of *P. æthurus*, preserved in the Museum of the College of Surgeons. Unfortunately, neither in the latter Museum nor in the National Collection is there a skeleton of the first-named species. On comparing the fossil with the proximal portion of the tarso-metatarsal of the Cormorant, *Graculus* (*Phalacrocorax*) *carbo*, I find that the form of the tibial condylar cavities, the intercondylar tuberosity, and the depth of the upper portion of the anterior channel dividing the outer and inner metatarsals, also

[1] Palæontological Memoirs, vol. i. pp. 23 and 26.
[2] *Op. cit.* tom. i. p. 250.

the oblique canal on the latter for the reception of the extensor tendon of the great toe; together with the calcaneal tendinal grooves, and what remains of the calcaneal process; approach so nearly in their general characters, that they indicate a bird, which, if not actually belonging to the genus *Graculus*, must be referred to a genus very nearly related to it. It differs from the common Cormorant, in having the anterior margin of the outer metatarsal less sharply ridged, aud in the inner not being so depressed immediately below the articular cavity, but descending by an easy incline to the tendinal groove of the first digit; it is also deeply depressed on either side of the calcaneal process.

Among the remains of birds from New Zealand, collected by Mr. (now the Honourable) Walter Mantell, and acquired by the British Museum, is an entire tarso-metatarsal of a species of Cormorant, so alike to the Siwalik fossil, that at first sight they might be considered as specifically the same. This bone has, however, not been identified, for, as with *Phæton*, no skeleton of *Graculus*, besides that of the common Cormorant, has been available to me for comparison; and, judging from the condition of the bone, the species can scarcely be considered extinct, but may be represented by one of the species of Cormorants still living in New Zealand, or alike common to those Islands and Australia.

Pelicanus Cautleyi, Dav.

The collection also contains two other avian fragments of interest, in so far that they prove that species of the Pelican were contemporaneous with the preceding; and that then, as now, the genus had a wide geographical range, remains of two or three species having been found in European Miocene deposits.

The specimens consist of the distal ends of ulnæ, and respectively represent two species of the above Totipalmate bird. The larger and most perfect is figured of the natural size upon the oft-quoted plate R (figs. 7, 7*a*, *b*).[1] It belonged to a bird somewhat smaller than the existing *Pelicanus mitratus* from India, represented by a skeleton in the National Collection; but the form of the trochlear articulations are essentially the same, as is also the external tendinal pit, with its short bony projection. It differs in the greater depth and elongation of the palmar trocheal depression, and in none of the Pelicans that I have examined is this depression so pronounced, and may be deemed a specific character. The shaft is also more compressed laterally, and is more ovate in section. The generic identity being established, I dedicate the species to its discoverer.

Pelicanus ? *Sivalensis*, Dav.

This fragment is not so perfectly preserved, and differs from the preceding in several points, notably, the shaft is not so compressed,

[1] Frequent reference has been made to this unpublished plate of bird-remains, by reason of its importance in denoting the special objects selected by Dr. Falconer for illustration and description in the "Fauna Antiqua Sivalensis," and by its occurring among the descriptions of the series of unpublished plates in Falconer's "Palæontological Memoirs," vol. i. p. 554. It is also of importance to notice the fact that these plates have all been photographed at the expense of the Geological Survey of India, and copies may be obtained of the Autotype Company, London.

and is sub-cylindric in section, the palmar trocheal depression is shallow, and not so elongate, the diameter of the cuneiform and magnum facets are narrower relatively to the length of the ulnar trochlea; and the carpal trochlear projection dividing the articulating surfaces of the scapho-lunare and magnum is more oblique. These differences I believe to be of specific, and not of generic value; nevertheless I refer it to *Pelicanus* with a note of interrogation. Appended are measurements of the fossils and of the distal end of the ulna of *Pelicanus mitratus*:—

	P. Sivalensis.	P. Cautleyi.	P. mitratus.
Length of fragment	1·5	1·5	...
Transverse diameter, including radial tuberosity	0·52	0·7	0·85
Antero-posterior diameter of ulnar trochlea	0·6	0·75	0·95
Transverse diameter of shaft at distal end	0·4	0·45	0·58
Antero-posterior diameter at ditto	0·5	0·6	0·65

There are a few other portions of avian bones still unnoticed, but I cannot determine their affinities satisfactorily. Although the remains of birds are few, when compared with the abundance of those of other classes of vertebrata found in these deposits, yet the following list of the species already determined, or noticed, will show that the class was well represented among the fauna whose bones have been preserved in the Siwalik rocks:—

Struthio asiaticus, A. M.-Edw.
Dromæus Sivalensis, Lyd.
Sp. indet., Brit. Mus. Coll.
Argala Falconeri, A. M.-Edw.
Megaloscelornis Sivalensis, Lyd.
Pelicanus Cautleyi, Dav.
——— ? *Sivalensis*, Dav.
Species allied to *Graculus*.

EXPLANATION OF PLATE II.

Fig. 1. Posterior view of the distal end of the tarso-metatarsal and phalange of *Struthio asiaticus*, A. Milne-Edw. *ph.* Phalange.
„ 2*a*. Upper view of second phalange of the middle toe of a new form of Struthioid bird.
„ 2*b*. View of the proximal articular surface of the same.
„ 2*c*. Side view of the same.
„ 3*a*. Side view of the second phalange of the middle toe of *Casuarius emeu*.
„ 3*b*. View of the proximal articular surface of the same.
„ 4. Palmar view of the distal extremity of the left humerus of *Argala Falconeri*, A. Milne-Edw.

All the figures are drawn of the natural size.

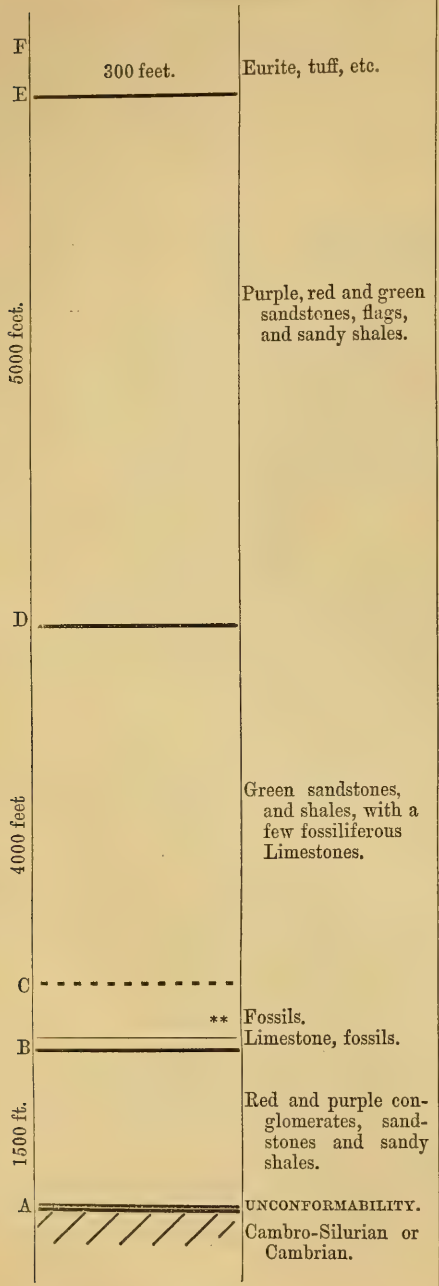
IV.—The Supposed Old Red Sandstone of the Curlew and Fintona Districts, Connaught and Ulster, Ireland.

By G. H. Kinahan, M.R.I.A.,
President of the Royal Geological Society, Ireland.

Since my former paper on the rocks of the Curlew and Fintona districts was published,[1] I have had an opportunity of more carefully examining these districts. Both are eminently favourable for the theoretical geologist, as in them the rocks are much obscured by drift; however, for a careful and painstaking explorer, there are sufficient sections exposed, to show the geological age of the rocks. The accompanying diagram represents the rocks as they occur in the Curlew Mountains district.

[1] Geol. Mag. February, 1879, p. 65.

Curlew Mountains Section, Cos. Mayo and Roscommon.



The rocks from A to C occur in a continuous section; those from C to D are not as well exposed, but sufficient of them are seen to show that from B to D they are about 4,000 feet thick; while the thickness from D to F had to be estimated. The eurites and tuffs (E to F) are of various thicknesses, but on an average they seem to be about 300 feet thick. Above the eurites there seem to be no rocks, or only a very slight thickness of rocks in the Curlew Mountain district; but in the Fintona district above this zone there are massive conglomerates, sandstone and sandy shales associated with some beds of limestone. The limestones may be of limited extent, as they were only remarked in one district.

As to the age of these rocks. Those below the unconformability at A, are metamorphosed and have been called Upper Silurians and Felstones. The latter name is so far correct, in that some of the rocks are granulites (metamorphic felstone), rocks which many Petrologists include among the felstones.

It is, however, perfectly incorrect to call any of them Upper Silurians; as they were metamorphosed, ruptured, upturned, and denuded, prior to the overlying Silurians having been accumulated. Their debris and fragments, in many instances, are largely found in the Silurian rocks, especially in the conglomerates between A and B. These metamorphosed rocks must belong to either the Cambro-Silurian or Cambrian age.

The rocks between A and B are similar to the rocks elsewhere called "Old Red Sandstone;" they, however, must be of Silurian age, as they occur in a continuous sequence, which underlies a limestone containing fossils, principally of Llandovery types.

The rocks between B and D in the vicinity of the place where Sir Richard Griffith, years ago, found Silurian fossils, have been thus classified; but in another locality, where the fossiliferous limestone was unknown, they have been called "Old Red Sandstone."

The sequence from the rocks between B and D is continuous up into the red and purple rocks in the sequence above the line D. It is, therefore, evident that the rocks above the horizon of D must be either the equivalents of a portion of the "Dingle Grits," or on a lower horizon. If this is correct, they must belong to the Silurian period.

If the country is traversed from Pomeroy, co. Tyrone, to Enniskillen, co. Fermanagh,—and from Drumshambo in Leitrim past Boyle (co. Roscommon) to Ballaghadereen, co. Mayo, and from thence by Croaghmoyle to Louisburgh and the Killarney districts, it will be found that the rocks of all these districts have similar aspects, as mentioned in my former paper; although only in some of them have fossils of Silurian types been found. To those already recorded, I would now add another; that is, Silurian fossils have been met with in the so-called "Old Red Sandstone" of the Curlew Mountain district. It should be mentioned that Sir Richard Griffith suggested this years ago.

V.—On Linnarsson's Recent Discoveries in Swedish Geology.

By Chas. Lapworth, F.G.S., etc.

In the present communication I propose to direct the attention of British Geologists to three most valuable memoirs recently published by Mr. G. Linnarsson, the eminent palæontologist of the Geological Survey of Sweden; and at the same time to point out, as briefly as may be, what appears to me to be their special bearing upon certain tentative or disputed points in British Geology. They treat of subjects of great interest to the student of the palæonto-geology of the Lower Palæozoic or Proterozoic Rocks; but are printed in the Swedish language, with which, unfortunately, few amongst us are familiar. The first two papers deal with the Graptolite-bearing rocks of Sweden; the third treats of the peculiar fauna of a recently-detected horizon in the prolific Paradoxidian or Primordial Zone.

Whatever concerns the Graptolite-bearing rocks of Sweden is at present certain to be received with respectful attention by the geologists of this country, from the fact that the Proterozoic strata of the shores of the Baltic retain their original horizontality, unaffected by those tremendous earth-movements which have so generally convulsed the Graptolite-bearing rocks of Britain. With ourselves, until very recently, the attempt to fix the specific succession of the Graptolites in time was looked upon by the vast majority of geologists as a task of almost hopeless, if not wholly insuperable difficulty. Even yet, among those whose special training has led them to look upon the apparent stratigraphy as all-in-all, it is practically denied that we possess unequivocal evidence that the Graptolites resembled the other great families of animals peopling the Proterozoic seas, in their subjection to that law of generic and specific progress and development in time to which we owe the successive and distinctive faunas that characterize our consecutive rock-formations. That any party of geologists, however influential, can long hold this indefensible and somewhat ridiculous opinion, is impossible. Nor, in all probability, would it ever have been adopted, but as a last and desperate means of temporary relief from the otherwise unaccountable difficulties brought about by the inevitable clashing of the true palæontological data with the abundant ocular proofs of ascending physical successions, in which the same faunas either re-appeared again and again unchanged, or underwent not a progressive, but a retrogressive modification. We are now beginning to acknowledge that it is not our palæontological, but our stratigraphical data that are at fault, and to admit the unreliability of apparent physical evidence in districts where the rocks are so frequently inverted and shattered as they are in many parts of Britain. However, even with us, as I have shown elsewhere, the unequivocal physical evidences demonstrate that the Graptolites are fully as reliable as other groups of fossils in the parallelism of synchronous deposits. Nevertheless, the distrust of palæontological data founded upon the specific succession of the Graptolitidæ in time has been so widely spread, and has had for so many years so apparently well-grounded an origin, that it is indeed gratifying to point to extra-British rocks—where perfectly parallel and consonant results with my own have been arrived at by authoritative scientific investigators among strata where the physical succession is indubitable.

In the South of Sweden, as a rule, the Proterozoic strata are horizontal, and although occasionally interrupted for short distances, the ascending succession of the consecutive rock-groups is perfectly clear and beyond question. Formations with us several thousands of feet in thickness are there represented by thin zones of only a few feet in vertical extent. Add to this the important fact that this miniature succession of deposits is so prolific in fossils that it suffers little or nothing in comparison with that of the enormous series of the Proterozoic strata of Britain, and the reliability and value of every new fact bearing upon the vertical distribution of the Swedish fossils, whether Graptolites or those of other families, is strikingly apparent. Among the modern earnest and conscientious students of these Swedish rocks we hear little or nothing of a belief in that supposed intertwining of the faunas of distinct formations, which, more especially since the promulgation of Barrande's theory of Colonies, has been the bane of British palæonto-geology; but we find on the other hand a well-grounded confidence, which gains daily consistency by each new discovery, that among the Cambrian, Ordovian, and Silurian systems there are in reality successive life-zones, marked off from each other by distinctive but related faunas, corresponding in all essential respects with those that mark off the successive stages in the much more recent Jurassics. The supposed recurrences of fossil groups disappear in the light of careful investigation. In all cases where this supposed upward or downward extension of fauna was said to obtain, it has now been shown that there is in truth no intermixture; but that the faunas are broadly distinct, except at their point of junction, and that the hypothetical intertwining was due to erroneous ideas of the natural order of physical succession, or was founded upon hasty generalization due to imperfect knowledge. This rapid elimination of error, together with the simultaneous filling up of the outlines of our knowledge of the faunas of the consecutive Swedish formations, has had its natural result in giving a remarkable definiteness to the ideas of the Swedish geologists with respect to the limits and palæontology of the rock-groups of their native country.[1] The acceptance of their new data by extra-Swedish investigators is certain in time to make its influence felt even amongst us, and will prove of inestimable advantage in aiding the rising generation of our geologists to throw off the present incubus of official use and wont, and in opening their eyes to a proper conception of the enormous time-period and the marvellous variety of the successive life-groups of the great Proterozoic Age.

The district described in this memoir is classic ground to the geologists of Sweden. Its fossils have been treated of in turn by Linnæus, Wahlenberg, Hisinger, and Angelin; and the sequence of its strata has engaged the attention of several famous scientific men. Hisinger's tabulation of the sequence has long been obsolete. Angelin was the first to recognize, with some approximation to correctness, the grander members of the series, and to indicate their characteristic fossils. Since his day much has been added to our knowledge of the lowest beds by the cautious investigations of Dr. Nathorst. Dr. Törnquist has made it the subject of two valuable papers, and through the more recent researches of Mr. Linnarsson our ideas of physical and palæontological succession are likely soon to be tolerably complete. His former paper, published in 1875,[2] embodied the conclusions drawn from the data collected by himself in a tour of the district, with the result of fixing the limits of the chief natural groups, of establishing several previously unrecognized subordinate divisions, and of harmonizing the whole with the general succession in other districts.

In his paper of 1875, the nomenclature of the Scanian Proterozoic

[1] *Observations on the Graptolite-bearing Schists of Scania.* By G. Linnarsson (Jakttagelser öfver de graptolitförande skiffarne i Skåne), Geol. Fören. Förhandl. Stockholm, 1879, No. 8, pp. 227-258, with a plate of sections.

[2] Geol. Förens. Fordh. 1875, Bd. II., No. 8.

Rocks proposed by Linnarsson was as follows, in descending succession :—

12. Upper Graptolite Schist.	6. Lower Graptolite Schists.
11. Brachiopod Schist.	5. Ceratopyge Limestone.
10. Trinucleus Schist.	4. Dictyonema Schists.
9. Chasmops Limestone.	3. Olenus Schists.
8. Middle Graptolite Schist.	2. Paradoxides Schists.
7. Orthoceras Limestone.	1. Sandstones.

According to Angelin's previous classification, Nos. 8 to 12 were merged in the single group of the *Clay Schist Series*, No. 7 was his *Öland Limestone*, and Nos. 2 to 6 were all lumped together under the general name of the *Alum Shales*.

Dr. Törnquist, in the year following, very properly proposed to do away with the titles of *Graptolite Schist*, and name these formations after their characteristic genus.[1] The *Lower Graptolite Schists* became the *Phyllograptus* Schists, the Middle Graptolite Schists were altered to *Dicranograptus* Schists, and the Upper Graptolite Schists were broken up into the two formations of the *Lobiferus* and *Retiolites* Schists.

In the present paper, Linnarsson gives a complete *résumé* of the results of his careful study of the details of the succession of the various *Graptolite Schists* during last summer. The following is a condensed summary.

1. *Lower Graptolite Schists* (or Phyllograptus Schists).

Under this name are included all the Graptolite-bearing strata that lie between the *Ceratopyge* and *Orthoceras* Limestones. They form a single zone of shale or laminated beds of dull dark colours, varying from greenish-grey to black. The Graptolite fauna has everywhere the same general character, consisting almost universally of various genera of the great family of the *Dichograptidæ*, and its closest ally the *Phyllograptidæ*. The commonest genera are *Didymograptus*, *Tetragraptus*, *Dichograptus*, *Temnograptus*, *Phyllograptus;* and the most abundant species are identical with, or representative of, those familiar to us in the Skiddaw and Quebec Groups—such as *Didymograptus patulus*, Hall, *constrictus*, Hall, *indentus*, Hall, etc.; *Tetragraptus quadribrachiatus*, Hall, *T. Bryonoides*, Hall, and *T. Bigsbyi*, Hall. *Dichograptus* is rare, but *Phyllograptus* is occasionally abundant.

The author points out the identity of this fauna with that which is characteristic of the Arenig in England, Wales, and Canada.

2. *The Middle Graptolite Schists* (or *Dicranograptus Schists*).

To these the author has devoted much labour, and, seconded by Herr Schmalensee, of the Swedish Survey, has succeeded in making out the entire succession among them. They consist everywhere of shaley beds not unlike those of the *Phyllograptus Schists*, from which they are separated by the great *Orthoceras* Limestone. They are rarely or never seen exposed in a continuous section, but with the aid of investigation of the natural exposures, and by means of excavations at critical points, the author has corrected and supplemented Törnquist's labours, and is able to render a fair account of the

[1] Geol. Förens. Fordhl. 1875, No. 10.

sequence both physically and zoologically. His typical section is that of Sularps Beck, near the classical locality of Fogelsäng. In the Middle Graptolite Schists here investigated Linnarsson recognizes eight successive palæontological subdivisions or zones, viz.:—

(*a.*) Zone with *Phyllograptus typus.*

Immediately upon the Orthoceras Limestone lies a series of green and black shales 20 feet in thickness. They are characterized by *Phyllograptus typus* (Hall?), numerous species of *Didymograptus*, both patulous and with parallel branches, and representatives of *Diplograptus Hopkinsoni*, Mich., *Climacogr. confertus* or *C. perexcavatus*, Lapw., and *Clim. Scharenbergi*, Lapw.

(*b.*) Zone with *Didymograptus geminus*, His.

This consists of a black shale, with harder beds of schist. No *Phyllograpti* are visible in this zone, which is characterized by the abundance of *Didymograptus geminus*, His., in association with a general fauna resembling that in the underlying zone, together with *Diplog. foliaceus*, Murch., and the genus *Corynoides*, Nich.

(*c.*) Zone with *Glossograptus Hincksi*, Hopk.

This zone is marked by a species doubtfully referable to *Glossograptus Hincksi*, Hopk., which occurs in great abundance. Here we find the first trace of the genus *Dicellograptus.* As in Wales, the earliest form is of the type of *Dicello. Moffatensis*, Carruthers. The tuning-forked-shaped (Murchisoni-form) species of *Didymograptus* have all vanished. One only remains with widely spreading branches.

(*d.*) Zone with *Diplograptus mucronatus ?* Hall.

In this, the most characteristic fossil is a most peculiar new diprionidian Graptolite, with characters superficially intermediate between the genera *Trigonograptus* and *Diplograptus.* With this are found *Diplograptus foliaceus*, Murch., *Diplogr. Hopkinsoni ?* Mich., *Diplograptus teretiusculus*, His., *Climacograptus caudatus ?* Lapw., *Dicellograptus sextans*, Hall, *Dicellograpt. Moffatensis ?* Carr., etc.

(*e.*) Zone with *Climacograptus Scharenbergi*, Lapw.

This is marked by the abundance of the species after which the zone is named;—a fossil very rare in the underlying zones. Its associates are:—*Diplograptus foliaceus*, Murch., *Diplograptus Hopkinsoni ?* Mich., *Diplograptus teretiusculus*, His., and *Didymograptus superstes ?* Lapw.

(*f.*) Zone with *Dicranograptus Clingani*, Carr.

The dark and pyritous shales that make up this zone contain here a few *Discinidæ*, together with *Diplograptus foliaceus*, *Climacograptus caudatus*, Lapw., and *Corynoides calycularis*, Mich. At Terrestadt they are much richer in these fossils, and yield in addition—*Dicellograptus Forchammeri*, Gein., *Dicellogr. Morrisi*, Hopk., *Dicranograptus Clingani*, Carr., *Climacograptus bicornis*, Hall, and others of the same genera, *Diplograptus quadrimucronatus*, Hall, and a species of *Lasiograptus.*

(*g.*) Zone of *Orthis argentea.*

The succession among the Middle Graptolite Schists is closed by a series of thick-bedded black schists, principally characterized by *Orthis argentea,* His., and an undetermined species of *Climacograptus.*

I will not follow the author into the discussion of the relationship of this last zone to the *Chasmops* and *Trinucleus* Shales, but will stay for a moment to glance at his attempt to parallel these Graptolitic Zones with their extra-Swedish representatives.

He does not definitively assign the (*a.*) *Phyllograptus* Zone either to the Arenig or Llandeilo. That question cannot, indeed, be satisfactorily settled until we know more of the Graptolites of the Lower Llandeilo and Upper Arenig.

(*b.*) The *Geminus* or *Murchisoni* Zone he rightly assigns most emphatically to the Lower Llandeilo, from the abundance of its characteristic fossil, which also occurs in millions in the Lower Llandeilo of South Wales.

The next three zones he parallels confidently with the Scotch Glenkiln Shales, or Lower Moffat. At the time his paper was published, this comparison was inevitable; but my studies of the Graptolite-bearing Llandeilo rocks of South Wales lead me to suspect that my Glenkiln Shales embrace only the higher zones of the beds that actually lie between the Ogygia-bearing, or so-called Middle Llandeilo, and the representatives of the Hartfell Shales; and I am at present inclined to the opinion that his zone (*e*) of *Climacograptus Scharenbergi* actually represents the whole of the Glenkiln Shales, the zones (*c*) and (*d*) not having yet been recognized in the South of Scotland.

His reference of the succeeding *Dicranograptus Clingani* and *Orthis argentea* zones to the general horizon of the Hartfell Shales of the South of Scotland, is, and will always probably remain, unassailable. If, however, they actually antedate the Trinucleus Shales of other districts of Sweden, they can only admit of comparison with the Lower Hartfell.

It is at present a matter of impossibility to parallel these Swedish beds with the three supposed Welsh formations of the Arenig, Llandeilo and Bala. The Lower Graptolite Schists and the Orthoceras Limestone are distinctly of Arenig age. The Murchisoni Bed of the Middle Graptolite Schist cannot yet be assigned either to the Arenig or the Llandeilo. Zones *b*, *c*, and *d*, I believe to be Llandeilo, while the last three zones are probably wholly of Bala age.

Upper Graptolite Schists (Monograptus Schists).—The final member of the Ordovian or Lower Silurian system of Sweden is the Trinucleus Schist, which, though the two have never actually been found in physical juxtaposition, probably overlies the *argentea* zone. The first member of the Silurian proper is the *Brachiopod Schist,* from which Graptolites are wholly absent. This is followed by a mass of Graptolitic Shales, dark and finely laminated at the base, but becoming lighter in colour and occasionally of coarser character higher up. The lower beds as exposed in Westrogothia, etc., have been denominated by Törnquist the "Lobiferus Schists." Wherever they occur in Scania they can be immediately recognized both by their marked mineral character and by their fossils. From these beds Linnarsson and Schmalensee have procured *Rastrites peregrinus,* Barr.; *Monograptus fimbriatus*, Nich.; *Monograptus cyphus*, Lapw.; *M. Sedgwicki*, Portlock; *M. millepedia*, M'Coy; *M. leptotheca*, Lapw.; *M. gregarius*, Lapw.; *Diplograptus palmeus*, Barr.; *Diplograptus folium*, His.; and *Climacograptus rectangularis*, M'Coy.

These beds the author parallels with the Birkhill Shales of the South of Scotland: indeed this comparison is inevitable. He points out with great effect how these beds are trenchantly separated from the Lower and Middle Graptolite Schists by the complete absence of nearly all the genera of Graptolites that occurred within them, and the complete families of the *Dichograptidæ* and the *Dicranograptidæ*, while they are themselves characterized by the abundance of the family of the *Monograptidæ*, which here makes its appearance for the first time.

The higher strata (*Retiolites Beds* of Törnquist) of the Upper Graptolite Schists are much more difficult of investigation, and their detailed study is as yet far from being complete. They are generally, but not exclusively, composed of greyish schists, more light than dark, with greenish seams, somewhat thick-bedded in character, occasionally including nodules of lime or marl. Their chief palæontological characteristic is the total absence from them of all diprionidian Graptolites with the exception of *Retiolites*. Among the monoprionidian forms the genus *Cyrtograptus* occurs here, for the first time; *Rastrites* however, appears already to be extinct.

No physical section in Scania is known in which the relationship of the *Lobiferus Beds* to the *Retiolites* Beds is shown, as in Westrogothia. The lowest zones of the Retiolites Beds are probably the grey shales of Tosterup, which contain *Monograptus crispus*, Lapw., in association with *M. lobiferus*, M'Coy. In the typical *Retiolites Beds* of Törnquist, as described by that investigator, at Rostånga, Herr Schmalensee detected *Retiolites Geinitzianus*, Barr.; *Monograptus priodon*, Bronn.; *Monogr. vomerinus*, Nich.; *Cyrtograptus Murchisoni*, Carr.; which mark the Retiolites Skiffar everywhere in Westrogothia and Dalarne.

This special group of fossils has often been met with at various spots in the district, both in beds of a harder and of a softer nature than those in what may be called the typical locality. The strata that afford them can be readily distinguished from the *Lobiferus* beds below, and from the typical *Retiolites Beds* above (with which Törnquist united them); and may be regarded as forming a distinct and separate horizon.

The *Retiolites Beds* themselves the author believes to be separable into two main groups: (*a*) the strata with *Monograptus testis*, Barr.; (*b*) the strata with *Monograptus colonus*, Barr.; though this is as yet not absolutely certain.

At Jerrestad and Tomarp occur dark grey, more or less thick-bedded schists, resembling the *Retiolites* schists of Dalarne (Törnquist's Spheroid-Schists). In these the commonest fossil is *Monograptus testis*, Barr. Its usual associates are *Monograptus colonus*, Barr. (or *Galaensis*, Lapw.), *Monogr. priodon*, Bronn., and a *Cyrtograptus*. These beds form the author's "Strata with *Monograptus testis*."

The beds that have the widest geographical distribution in Scania are the author's "Strata with *Monograptus colonus, Barr.*" They consist as a rule of grey or greenish, irregular, tolerably thick-bedded and often calcareous schists, with obscure traces of fossils. The commonest form is *Monograptus colonus*, Barr., *M.* sp. nov. resembling *M. concinnus*, Lapw., and one or two additional species.

The most characteristic fossil of these beds, however, is *Cardiola interrupta*, Brod. These "Colonus beds" are easily distinguished from the underlying strata by their physical peculiarities, and are, according to Linnarsson, in all probability the highest Silurian strata in Scania. He believes that they are of younger age than any of the Silurian beds of Westrogothia and Dalarne. Many of the fossils of the "Strata with *M. testis*," and the "Strata with *M. colonus*," are met with in the Riccarton beds of the South of Scotland, and with these, rather than with the certainly older Gala group, the author is inclined to parallel them.

With respect to his so-called Lobiferus-Beds, I am inclined to think that they are of much greater systematic value than Linnarsson is apparently willing to consider them. To judge from the specimens of these beds I have actually seen, I am inclined to parallel their most prolific zone with the base of Upper Birkhill or top of Lower Birkhill, where the true *M. lobiferus* of M'Coy is abundant and characteristic, as indeed are all the fossils of the typical *Lobiferus beds.* There are, however, in the British Valentian or Llandovery rocks great thicknesses of fossiliferous strata both above and below this special horizon. It is not unlikely that the Brachiopod Schists stand in the place of the Lowest Llandovery, and therefore of the lowest beds of the Birkhill. But where is the Swedish representative of the great Gala group of South Scotland and the Tarannon of Wales? This highest Valentian formation swarms with what may be called, for the sake of illustration, varieties of *M. lobiferus*, such as *M. exiguus*, Nich., and *M. Becki*, Barrande. These occur in millions in the Gala Group and the Tarannon of North Wales, with a slight intermixture of true Wenlock forms, such as *Retiolites Geinitzianus* and *Monograptus priodon.* I am at present inclined to the opinion that the Swedish geologists will find these Tarannon beds in the highest stages of their *Lobiferus Schists*, as well as in the grey *M. Crispus* shales of Tosterup. I look forward with confidence that in the event of their discovery, they will be found to be characterized by similar *lobiferous* species.

Linnarsson's discovery of the *Zone of Cyrtograptus Murchisoni* in Sweden is indeed a matter of great interest. This zone, never many feet in thickness, forms the basal bed of the Wenlock formation in Britain. I have traced it at the base of the Wenlock of Builth, in Shropshire, in North Wales, and in the Lake District, holding invariably the same stratigraphical position, and affording precisely the same fossils. This enables us to fix the immediately superior Swedish strata as of true Wenlock age.

Though I know of at least two newer zones in the Wenlock-Ludlow or Salopian strata of Britain, I have never recognized anything that can be strictly paralleled with Mr. Linnarsson's *Zone of Monograptus testis*, Barr.

As I treat elsewhere[1] of the details of the correspondence between the various Graptolitic zones of Britain and foreign countries, it will be unnecessary for me to go more fully into the subject in this place. I trust, however, that the foregoing sketch will make it evident how greatly geologists are indebted to the author for the wide extent and minute accuracy of his researches, and the cautious and conscientious manner in which he has drawn his important and far-reaching generalizations.

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

NOTICES OF MEMOIRS.

Report on the Fossil Flora of Sheppey.[2] By Dr. Constantin Baron Ettingshausen, Professor in the University of Graz, Austria.

ONE of the most important, if not the most important, locality for the Eocene Flora of Great Britain, and perhaps of the Tertiary formation generally, is the London Clay of the Isle of Sheppey, in which are found great numbers of plant remains belonging to many different kinds of fossil fruits and seeds. After an examination of the rich collection in the British Museum, I feel now sure that we possess, in the fruits and seeds of Sheppey, the key to a more precise determination of many of the genera and species of fossil plants which in other localities are known only by their leaves.

The literature of the Sheppey fruits is not very extensive; a detailed account of all the works relating to it is published in the Palæontographical Society, 1879, p. 11, Mr. Gardner's "Introduction to our Monograph on the British Eocene Flora." The only work on this subject with scientific determinations, and which need here be referred to, was published in the year 1840 by James Scott Bowerbank, and is entitled "A History of the Fossil Fruits and Seeds of the London Clay." He enumerates twelve genera, which are divided by him into nine families. The genera are as follows: *Nipadites, Hightea, Petrophiloides, Cupressinites, Cupanoides, Tricarpellites, Wetherellia, Cucumites, Faboidea, Leguminosites, Mimosites, Xulinosprionites.* Of these only one (*Nipadites*) belongs to the Monocotyledons, and one (*Cupressinites*) to the Gymnospermæ, while the rest are Dicotyledons.

I am now able materially to advance the knowledge of this Flora. Since my investigation in the course of the winter 1878-9, at the British Museum, I have ascertained that the Fossil Flora of Sheppey contains, including those above mentioned, at least 72 genera and 200 species, which may be distributed into 41 families. Of these genera one belongs to the Thallophyta, 7 to the Gymnospermæ, 18 to the Monocotyledons, 43 to the Dicotyledons, and 3 are indeterminable.

The existence of this Flora and generally of the Eocene Flora of Great Britain required, we believe, at least, a sub-tropical climate. This

[1] *Lapworth.*—Geological Distribution of the Rhabdophora, Annals and Mag. Nat. Hist. 1879.

[2] Abstract of the Proceedings of the Royal Society, Nov. 27, 1879.

is indicated by many of the Ferns and Palms, and by the Musaceæ, Pandanæ, Cinchonaceæ, Loganiaceæ, Sapotaceæ, Ebenaceæ, Büttneriaceæ, Sapindaceæ, etc.

Only a part of the fossil fruits and seeds of Sheppey can be placed in living genera; but with regard to the rest, forming a considerable proportion, it has been found impossible, notwithstanding a careful comparison. I therefore assume that some of the fruits and seeds belong to genera which no longer exist in the present Flora of the world. In several of these extinct genera, however, I recognize their affinity with living genera, or at least determine the family to which they belong. I have expressed this in the name of the genus. But with many even that was impossible, and these I have placed in the mean time under the provisional name *Carpolithes*. It is an important fact that the number of such extinct forms is relatively much larger than it is in any of the already known Miocene Floras. I have also discovered fruits, but chiefly leaves, belonging to many of the genera of the Sheppey Flora in the Fossil Floras of Bournemouth and Alum Bay in the collections of the British Museum, and that of Mr. John Starkie Gardner, indicating that in age these are not far removed. It is well known that the Sheppey Flora preceded the other two. The genera which, I feel sure, are common to Sheppey and Bournemouth are: *Sphæria, Sequoia, Cyperites, Smilax, Sabal, Iriartea, Aronium, Quercus, Juglans, Liquidambar, Proteoides, Laurus, Nyssa, Cinchonidium, Apocynophyllum, Sapotacites, Diospyros, Magnolia, Acer Sapindus, Cupania, Eugenia, Eucalyptus, Metrosideros*, and *Bauhinia*.

I believe that even some species of these genera are the same in both Floras. It is surely probable that the fruits and seeds of Sheppey were related to the leaves found at Bournemouth and Alum Bay; and it would be, therefore, undesirable always to propose separate specific names for the related fossils found in these different localities.

Among the plant-fossils of Bournemouth and Alum Bay I also found many leaves which I could not class with existing genera. There is probability that these partially correspond with the extinct fruit- and seed-genera of Sheppey.

Before I enumerate the genera and species of the Fossil Flora of Sheppey, I have to remark as follows:—

Amongst the Sheppey fossils are now and then found fragments of the basis of the leaf of a Palm, probably of *Sabal major*. On such a fragment I found the apothecia of a *Sphæria*. Of the Gymnospermæ of Sheppey there were found fruits and seeds of the *Sequoia Bowerbankii*, also fragments of twigs. The seeds of the *Cupressineæ* and *Abietineæ* had lost their wing-like expansions, which shows that the fruits and seeds of Sheppey were carried some distance in water, consequently their delicate membranous wings were injured and broken off by rubbing. There are therefore no perfect winged fruits and seeds to be found. In fact, even the firmer wings of the Acer-fruit have been entirely lost, and it is impossible to determine the species of the Acer-nucules, which remains.

The appearance of the *Salisburia* seeds is interesting. They are very remarkable for their sharp, prominent edge. The easily-determinable leaves of this genus have not as yet been found in the Eocene Flora of Great Britain.

The *Agave* is indicated by a valve of its fruit; *Smilax*, of which leaves are not unfrequently found at Bournemouth, is indicated by a berry. Of *Musa*, of which only leaves had as yet been found, there are seeds. Of *Amomum*, two kinds of fruit have been found. These have hitherto been mistaken for smaller fruits of the *Nipadites*. Of particular interest are the many species of Palms. The fruits and seeds of some, for instance, *Sabal major*, *Trinax Bowerbankii*, *Elæis eocenica*, *Iriartea striata*, *Livistona eocenica*, have been found. Of the *Sabal* and *Iriartea* the leaves are found at Bournemouth. The *Elæis eocenica*, the most common Palm of the Sheppey Flora, is nearly allied to the *E. melanococca*, and the *Livistona eocenica* to the *L. chinensis*.

I do not yet know whether the *Aroidea* seed, which I have placed in *Aronium*, might be united with the *Aroidea* leaf of Bournemouth. On the other hand, I think it is very likely that some of the kinds of oak fruits correspond with some of the kinds of oak leaves, which are to be met with at Bournemouth. Two of the Bournemouth species are also found in the Miocene Flora, and one of these, *Quercus lonchitis*, also in other Eocene Floras.

A small nut shows all the characters of the *Corylus*, which is found in the Miocene Flora. The absence of *Fagus* is very remarkable, as two kinds of leaves, which can only belong to this genus, have been found in Bournemouth. *Fagus* is frequently found in the Miocene and Post-Tertiary formations, and also in the Cretaceous formation, and I believe, therefore, that it may still be found in Sheppey.

The fruit of *Liquidambar* from Sheppey may belong to the same species as the inflorescence of *Liquidambar*, which I found amongst the fossils of Bournemouth. The berry of *Laurus*, which I have found amongst the Sheppey fruits, is placed by me in *Laurus Lalages*, the leaves of which have been not only found in Bournemouth, but also in the Austrian Eocene (Sotzka, Hæring), where they occur associated with berries.

The occurrence of a species of *Nyssa*, I think, may be also accepted for the Bournemouth strata. Of the Proteaceæ, besides *Petrophiloides*, a seed belonging to the Proteæ occurs, perhaps corresponding with the leaf which I have seen among the fossils of Alum Bay. In Bournemouth and Alum Bay were found the seeds of some other Proteaceæ which are not in Sheppey, as they have delicate wings. Some of the cones referred by Bowerbank to *Petrophiloides* belong to *Sequoia*.

The Gamopetalæ are represented by many genera, of which almost all appear also in the Miocene Flora. The fruit of *Cinchonidium* of Sheppey and the leaves of a species of *Cinchonidium* from Bournemouth may belong together. I accept the same for the *Apocynophyllum* fruit of Sheppey and the corresponding leaf of Bournemouth. This last accords in all its characters with *A. Reussi*, which also appears in the fossil Flora of Sagor. But I have not found up to the present time, in the Eocene Flora of Great Britain, any leaf belonging to the characteristic genus *Strychnos,* the seeds of which are met with at Sheppey.

Of the Sapotaceæ there are two species of seeds, which perhaps correspond with two species of Sapotaceæ leaves of the Bournemouth Flora. One of these extends throughout in the Tertiary Flora; the other, on the contrary, seems to be peculiar to the Eocene Flora. Also peculiar to this Flora are two species of *Diospyros,* which are common both to Sheppey and Bournemouth.

The species of *Symplocos* is common to Sheppey and Sagor. In these two localities the putamen of this species were found. In corresponding abundance are represented the Dialypetalæ. They are specially characteristic of the Eocene Flora in general, and of the Sheppey Flora in particular. To the first belong species of *Magnolia, Eugenia, Sapindus, Metrosideros,* and *Bauhinia,* whose leaves or fruits are to be found associated together in Bournemouth. To the last belong the genera *Menispermacites, Victoria, Thlaspidium, Corchorites, Theobroma, Lawsonia*; and species of *Illicium, Nelumbium, Cucumites, Cotoneaster, Prunus, Amygdalus, Podogonium,* etc. Belonging also to other Eocene Floras and to the Miocene Flora we have here only the Dialypetalous plants, *Nelumbium Buchii,* and *Eucalyptus oceanica.*

Amongst the fruits and seeds of Sheppey we find also some species of herbaceous or tender plants whose leaves would not be preserved in the Tertiary strata. To these belong the seeds of *Solanites, Menispermites, Cucumites,* the fruits of *Thlaspidium,* and of *Corchorites.*

And in conclusion I desire to express my thanks to the Royal Society for the important assistance it has rendered me by the grants from its funds by which I have been enabled to prosecute my investigations in England; and for personal assistance in this work I desire to record my indebtedness to Sir Joseph Hooker, C.B., Dr. Henry Woodward, F.R.S., Mr. William Carruthers, F.R.S., and Mr. John Starkie Gardner, F.G.S., etc.

The descriptions and illustrations of the species, here enumerated, will appear in the Monograph now in course of publication by the Palæontographical Society.

Genera and Species of the Fossil Fruits and Seeds of Sheppey.

Thallophyta.

Sphæria, 1 sp.

Gymnospermæ.

Cupressineæ.—Callitris (*Cupressinites,* c. Bowerb.), 2 sp. *Solenostrobus* (*Cupressinites,* s. Bowerb.), 4 sp. *Hybothya* (*Cupressinites,* c. Bowerb.), 1 sp. *Cupressinites,* Bowerb., 4 sp.

Abietineæ.—Sequoia (*Petrophilides,* Bowerb.), 1 sp. *Pinus,* 1 sp.

Taxineæ.—Salisburia, 1 sp.

Monocotyledones.

Cyperaceæ.—Cyperites, 1 sp.

Liliaceæ.—Agave, 1 sp.

Smilaceæ.—Smilax, 1 sp.

Najadeæ.—Caulinites, 1 sp.

Musaceæ.—Musa, 1 sp.

Zingiberaceæ.—Amomum, 2 sp.

Pandaneæ.—Nipa, 5 sp.

Palmæ.—Oenocarpus, 1 sp. *Areca*, 2 sp. *Iriartea*, 2 sp. *Livistona*, 1 sp. *Sabal.* 4 sp. *Chamærops*, 1 sp. *Trinax*, 1 sp. *Bactris*, 1 sp. *Asterocaryum*, 1 sp. *Elæis*, 1 sp, *Aroideæ.—Aronium*, 1 sp.

DICOTYLEDONES.

APETALÆ.

Cupuliferæ.—Quercus, 3 sp. *Corylus*, 1 sp.
Juglandeæ.—Juglans, 1 sp.
Euphorbiaceæ.—Euphorbiophyllum, 1 sp.
Balsamifluæ.—Liquidambar, 1 sp.
Proteaceæ.—Petrophiloides, 1 sp. *Proteoides*, 1 sp.
Laurineæ.—Laurus, 1 sp.
Nyctagineæ.—Nyssa, 1 sp.

GAMOPETALÆ.

Cinchonaceæ.—Cinchonidium, 1 sp.
Loganiaceæ.—Strychnos, 1 sp.
Apocynaceæ.—Apocynophyllum, 1 sp.
Solanaceæ.—Solanites, 1 sp.
Sapotaceæ.—Sapotacites, 2 sp.
Ebenaceæ.—Diospyros, 2 sp.
Symploceæ.—Symplocos, 1 sp.

DIALYPETALÆ.

Menispermaceæ.—Menispermacites, 1 sp.
Magnoliaceæ.—Magnolia, 1 sp. *Illicium*, 1 sp.
Cruciferæ.—Thlaspidium, 1 sp.
Nymphaeaceæ.—Nelumbium, 2 sp. *Victoria*, 2 sp.
Cucurbitaceæ.—Cucumites, 1 sp.
Büttneriaceæ.—Theobroma, 2 sp.
Malvaceæ.—Hightea, 8 sp.
Tiliaceæ.—Apeibopsis (*Cucumites*, Bowerb.), 1 sp. *Corchorites*, 2 sp.
Acerineæ.—Acer sp.
Sapindaceæ.—Sapindus, 1 sp. *Cupania* (*Cupanoides*, Bowerb.), 8 sp.
Myrtaceæ.—Eugenia, 1 sp. *Eucalyptus*, 1 sp. *Metrosideros*, 1 sp.
Lythrarieæ.—Lawsonia, 1 sp.
Pomaceæ.—Cotoneaster, 1 sp.
Amygdaleæ.—Prunus, 2 sp. *Amygdalus*, 2 sp.
Papilionaceæ.—Podogonium, 1 sp. *Bauhinia*, 1 sp. *Faboidea*, 26 sp. *Leguminosites*, 18 sp. *Xulinosprionites*, 2 sp. *Mimosites*, 1 sp.

PLANTÆ INCERTÆ SEDIS.

Wetherellia, 1 sp. *Tricarpellites*, 7 sp. *Carpolithes*, 37 sp.

REVIEWS.

GEOLOGY OF THE PROVINCES OF CANTERBURY AND WESTLAND, NEW ZEALAND. By JULIUS VON HAAST, PH.D., F.R.S. (Christchurch, 1879.)

THIS report is the result of a series of explorations carried on by Dr. Haast from 1860 to 1876, and embodies in a condensed form a description of the chief geological and physical features of the provinces of Canterbury and Westland in Southern New Zealand. Owing to the other official duties of the author as Director of the Canterbury Museum interfering with the continuous preparation of the work, the publication has been unavoidably delayed.

It is divided into three parts—the first part, on the progress of the geological survey, contains a descriptive account of the various journeys in different parts of the provinces, pleasantly written and in a popular form, so that the general reader may obtain a great deal of information on the physical geography, geology, zoology, and botany of the region, than purely scientific reports can generally convey to him; at the same time he will fully appreciate (from the details given) the dangers and difficulties of a field geologist who seeks his way in an unknown country without a map to guide or information to assist him. However, the grand scenery traversed, as partly illustrated by the series of lithographs inserted in the work, the interesting glacial and other phenomena observed, the diversity and beauty of the flora, must have partly compensated for the arduous labours incident to these explorations. Although many details are given in the first part as to the physical aspect of the Southern Alps, the physical geography of the provinces is more specially described in the second part, which treats of the orographical features and the nature and extent of the glaciers, rivers, lakes, and plains.

The Southern Alps (the principal watershed of which is the boundary-line between the two provinces) form part of the high longitudinal chain running from S.W. to N.E., and constitutes the main axis and characteristic feature of New Zealand. They consist almost entirely of Palæozoic rocks (the granitic axis is only exposed in Westland), thrown in large steep folds, which have been so much denuded, that the synclinals, or lower portions of the folds, now form the summits of the mountain ranges, whilst the valleys are generally formed along the anticlinals or saddles. It is partly owing to the orographical features that the climate on both sides the Alps has been so remarkably modified. The western side falls almost precipitously towards the sea, while the eastern side slopes down much more gradually. Extensive fields of perpetual snow repose on the slopes, from which large glaciers descend far into the valleys, but the snow-line on the western side of the Alps is much lower when compared with the eastern slopes, owing to the far greater rainfall on that side. "This difference is well exhibited by the great Tasman glacier, which, although of much larger dimensions than the Francis Joseph glacier, yet descends only to 2456 feet above the sea-level, whilst the latter reaches more than 1700 feet lower, namely, to 705 feet above the sea."

The third part is devoted to the geological structure, and consists of a series of chapters containing descriptions of the extent, character, and position of the rocks and strata which Dr. Haast has recognized as occurring in the provinces. Local names are applied to most of the formations, and which are considered respectively to represent, the Azoic, Silurian, Carboniferous?, Cretaceo-Tertiary, Miocene, Pliocene, Quaternary, and Recent periods.

In the chapter on economical substances, it is noticed that, though gold and some other metallic ores occur in Westland, the geological features of the Canterbury province are not favourable for their presence. Although the older Coal-measures similar to those of New South Wales are wanting, extensive and valuable beds of brown coal occur in the Waipara (Cretaceo-Tertiary) and Oamaru (Miocene) formations, especially in the former. The chapters on the Great Glacier formation and the Quaternary and Recent periods will interest the glacialist and anthropologist; the latter section treats of the first appearance of man in the island, the occurrence of Moa bones and the extinction of the Dinornithidæ, and a notice of the deposits at Glenmark, which have yielded the largest quantity and variety of Moa bones.

This work will form a useful guide to the geological structure, economical products and general character of the provinces described, while much interest and instruction will be derived from the vivid descriptions of the grand scenery of the Southern Alps, whose present physical features have chiefly originated or been greatly modified (see p. 173) during the great Ice Period, when glaciers far more extensive than the present ones descended and spread over the lower regions (as shown in Map, pl. ii.), disintegrating and denuding the contorted and elevated crystalline rock and other formations, scouring out the valleys, and transporting the morainic matter far and wide—the extensive distribution of which fully indicates the former more powerful and long-continued action of the Post-Pliocene glaciers. "The action of the giant ice ploughs, as we may call these glaciers, has essentially assisted in preparing the lower regions for the use of man, since by it the narrow valleys have been widened, the rugged mountains rounded off, and large plains have been formed" (p. 189). The report also contains a geological map and numerous sections, illustrative of the third part, as well as a series of lithographs, representing the finest scenery in Canterbury and Westland.

J. M.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 19, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Supplementary Note on the Vertebræ of *Ornithopsis*, Seeley (=*Eucamerotus*, Hulke)." By J. W. Hulke, Esq., F.R.S., F.G.S.

The author in this communication describes several cervical and trunk vertebræ of this remarkable Dinosaur. The former are characterized by great length; the anterior articular surface is strongly convex, and the posterior correspondingly hollow. In place of the side chamber characterizing the trunk vertebral centra, is a long shallow pit. An upper and a lower transverse process are given off from an upper and a lower plate, which project from the side of the centrum above the pit, and these are connected by a short, forked cervical riblet. The neural arch is dwarfed, and there is no spinous process, and no zygosphenal and zyganteal mechanism. The structure of these vertebræ indicates a long, mobile, and light neck. In the trunk the convexity of the anterior articular surface lessens in passing from the neck to the loins, the anterior ball gradually subsiding till the great articular surface becomes plane, the posterior surface retaining, however, a slight hollowness. The trunk vertebræ have superadded to the ordinary articular processes a mechanism comparable to zygosphene and zygantrum, which must have given great fixity to this part of the vertebral column, contrasting strongly with the flexibility of the neck. The longitudinal side chambers reach their greatest development in the vertebræ referable to the fore part of the trunk; they lessen toward the loins, and are absent from the neck, which is regarded as conclusive of their pneumaticity, and against their having been occupied by cartilaginous and fatty tissues, which might have equally occurred through the whole length of the vertebral column, and not been limited to a particular region in close vicinity to the lungs. The whole construction affords a notable illustration of immense bulk attained with the use of the smallest quantity of bony tissue, which occurs in the form of very thin sheets or plates. The transverse and spinous processes are strengthened by flying buttresses. The vault of the neural canal is beautifully groined, whence the original name *Eucamerotus*. The author then pointed out the family resemblances between this Isle-of-Wight Wealden form and the new Colorado Dinosaurs, which have many points in common, but are both generically and specifically distinct from *Ornithopsis*.

2. "On the Concretionary Patches and Fragments of other Rocks sometimes contained in Granite." By J. A. Phillips, Esq., F.G.S.

Patches resembling fragments of other rocks frequently occur in granite, sometimes angular, sometimes rounded, sometimes with clearly defined boundaries, sometimes melting away into the surrounding mass, generally finer in grain than the latter. After a sketch of the literature of the subject, the author described the results of chemical and microscopic investigations of these patches in the granites of Cornwall, Shap Fell, Aberdeen, Peterhead, Fort William, and North-eastern Ireland. There are two classes of inclusions, (1) the result of the abnormal aggregation of the minerals constituting the granite itself, containing generally more plagioclastic felspar, mica, or hornblende than it, with some other distinctions: most probably concretions formed contemporaneously with the solidification of the mass; (2) fragments of included schistose or slaty rock, often not very highly altered, caught up from the rock-masses through which the granite has forced its way.

3. "Certain Geological Facts witnessed in Natal and the Border Countries during Nineteen Years' Residence." By the Rev. George Blencowe. Communicated by the Rev. H. Griffith, F.G.S.

Shales and sandstones are the prevalent rocks from the coast for about twenty-four miles inland. Here is a protrusion of granite; beyond the sandstones come ferruginous shales, with scattered boulders of trap on the surface. The northern third of Natal is white sandstone, formed into hills and ridges by denudation, with a long trap-capped plateau near Helpmakaar. Coal-seams occur in the sandstones. There are frequent vertical pipes in these sandstones which, the author thinks, mark the site of trunks of trees, round which the sand-beds had accumulated. Rorke's House and Isandhlwana are near the above plateau. Near the former is an extinct mud volcano. A remarkable "vitreous shale" is found near the Buffalo; isolated pinnacles of it occur at the spot where the few survivors of the fight crossed that river. A range of mountains, with mural escarpments, remnants of an ancient plateau, rising to a height of some 2000 feet above another plateau which is 5000 to 6000 feet above the sea, extends for about 500 miles from the north of Natal to near Cradock in the Cape Colony; they are sandstone horizontally stratified, capped by trap. Some other geological features are described. The Transvaal consists of undulating hills of soft limestone, a sandstone range, and a country rich in metals—iron-ore, cobalt, nickel, copper, and gold occur, as well as plumbago.

II.—December 3, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Gneissic and Granitoid Rocks of Anglesey and the Malvern Hills." By C. Callaway, M.A., D.Sc., F.G.S.; with an Appendix on the Microscopic Structure of some of the Rocks, by Prof. T. G. Bonney, M.A., F.R.S., Sec.G.S.

The author described the results of his investigations into the stratigraphy and petrology of the above districts, which have led him to the following conclusions: — 1. The granitoid (Dimetian) rocks of Anglesey pass down into an anticlinal of dark gneiss (above) and grey gneiss (below). 2. Associated with the granitoid series are bands of felsite, hälleflintas, and felspathic breccias. 3. The succession of gneissic and granitoid rocks in Anglesey resembles so closely the metamorphic series of Malvern as to justify the correlation of the two groups. 4. The Pre-Cambrian rocks of Anglesey and the Malverns, from the highest known member down to the base of the gneiss, may be thus classified:—A. Pebidian (to be described hereafter); B. Malvernian; (*a*) Dimetian, with associated quartz-felsites and hälleflintas (Arvonian) passing down into (*b*) Lewisian.

2. "Petrological Notes on the Neighbourhood of Loch Maree." By Prof. T. G. Bonney, M.A., F.R.S., Sec.G.S.

The author had visited the upper end of Loch Maree and its vicinity with a view of seeing whether microscopic examination threw any light on the vexed questions as to the age of the newer gneiss, etc. He described the microscopic structure of a typical series of the Hebridean gneiss, and gave reasons for considering the mass of rock on the right bank of Glen Laggan to be not an intrusive "syenite," as has usually been supposed, but a mass of the Hebridean gneiss faulted against the *newer* series. The microscopic structure of the Torridon Sandstones was described; it proves that, as previously asserted, they are made up of the *débris* of the Hebridean series; from this also probably came the materials of the quartzites. By examination of specimens, collected both in Glen Laggan and at other points along the northern escarpment of the *newer* series, the author showed that its rocks have been rightly called metamorphic; and then, by comparison of these with specimens collected in Glen Docherty, he concluded that the latter belonged to the *newer* series, and that no part of the Hebridean series reappeared here (which would require a most unusual unconformability). On Ben Fyn also he could find no trace of the older series, the rocks there, where not igneous, resembling the *newer* series, though more highly altered than it is further north. The paper concluded with some remarks upon the bearing of the evidence obtained from these studies upon questions of metamorphism, especially as regards its "selective" action.

3. "On some Undescribed Comatulæ from the British Secondry Rocks." By P. Herbert Carpenter, M.A., Assistant Master at Eton College.

This communication contains descriptions of seven new Comatulæ from the Cretaceous and Oolitic series of Southern England, together with some new facts respecting the *Glenotremites paradoxus* of Goldfuss, from the Upper Chalk. This species is remarkable for the presence of certain characters which are very conspicuous in the recent *Antedon Eschrichtii*, and also in a new species dredged by the 'Challenger' at Heard Island in the South Atlantic, namely, the presence of strong ribs on the inner wall of the centrodorsal, five of which, interradial in position, are much more prominent than the rest. So far as is yet known, these features occur in no other recent Comatula, with the exception of one species from the South Pacific, in which there is a faint indication of such ribs; but they are all equal. Another *Antedon*-species is described from the Chalk of Sussex. It differs from *Antedon paradoxus* in the absence of these ribs, and in the shallowness of the centrodorsal cavity.

Two species are described from the Gault of Folkestone. One is an *Antedon* with no special relations to any recent forms. It might have lived as well at 20 as at 500 fathoms. But the other species is an *Actinometra*, possessing certain characters only known to occur in species from quite shallow water, 20 fathoms or less, in the Philippine Islands and Malay Archipelago. The centrodorsal is a flat plate, nearly on a level with the surface of the radials, or sometimes even below them, separated from them by clefts at its sides, and entirely devoid, not only of cirrhi, but also of cirrhus-sockets. This condition is only an extreme stage of the metamorphosis of the centrodorsal piece, which bears cirrhi for a time after its liberation from the larval stem; but these cirrhi eventually disappear and their sockets become obliterated. The 'Challenger' collection contains a series of specimens of *Act. Jukesii* from Torres Straits, which illustrate this point very completely; and it is therefore of no small interest to find a fossil Comatula which shows one of the extreme stages of the metamorphosis.

The large size of the three *Antedon*-species from the Chalk and Gault is very remarkable. *Ant. paradoxus* has a centrodorsal half as wide again as that of any recent form; while *Ant. Eschrichtii* is the only recent species with a centrodorsal approaching the size of those of the other Chalk *Antedon*, and of that from the Gault. *Act. Lovéni* from the Gault, however, and the older Comatulæ, all had small calices like most recent species. An elegant centrodorsal (*Ant. rotundus*) is described from the Haldon Greensand, and also two species from the Bradford Clay. One is an *Antedon*, the oldest known, with no special characters; the other is an *Actinometra*, with a centrodorsal essentially like those of species now living in shallow water in the Philippines and Malay Archipelago. The oldest known Comatula, an *Actinometra* from the Bath Oolite, has similar relations.

CORRESPONDENCE.

PETROLOGICAL NOMENCLATURE.

Sir,—Mr. S. Allport's excellent paper on "The Rocks of Brazil Wood" (Vol. VI. p. 481) incidentally suggests a general question to which, at the present time, it may be worth while calling attention. In this particular case, however, I am not persuaded that the name "micaceous schist" is any better than "gneiss" for the Brazil Wood rock. In writing of it I left the name gneiss, which had already been applied to it, unchanged, because I was not able to suggest a better. The foliation is so slight, as Mr. Allport observes, that the name schist (which calls attention to that property) does not seem appropriate; and we are not unfamiliar with rocks, to which we at present extend the term gneiss, which exhibit that phenomenon very imperfectly. A more serious objection is, as Mr. Allport remarks, that there is generally no felspar visible. The microscope, however, shows a third constituent, and the analysis[1] suggests the presence of an aluminous mineral. In this, if we assume that all the magnesia is present in a magnesia-mica, and all the soda in a soda-mica, we find (using rough approximations founded on some of the analyses given in Dana's Mineralogy) that to form these micas we require for the one about $SiO_2 = 4{\cdot}6$ $Al_2O_3 = 2{\cdot}2$ $FeO = 2$, $K_2O = {\cdot}8$; and for the other about $SiO_2 = 7{\cdot}0$ $Al_2O_3 = 4{\cdot}2$ $FeO = {\cdot}3$. Thus we have still left unemployed about $SiO_2 = 42{\cdot}4$ $Al_2O_3 = 15{\cdot}47$, $K_2O = 2{\cdot}8$; this (with the H_2O) seems to indicate some zeolite, which may have resulted from the destruction of a felspar. The rock then, though not strictly speaking a gneiss at present, may have been a kind of gneiss; though, under the circumstances, it is also possible that the felspathic constituent passed at once from the state of mud to its present condition.

This rock, then, is an example of a class of difficulties unpleasantly familiar to every petrologist. With an abundance of synonyms in some cases, our nomenclature is very defective in others. Thus, following the lead of the older geologists, it does not recognize clearly enough that the metamorphic rocks are not so much a third class independent of the other two[2] and of equal value, but that every rock, whether igneous or stratified, may have its metamorphic representa-

[1]

Water	= 4·23	CaO	= 2·13
SiO_2	= 54·01	MgO	= 1·30
Al_2O_3	= 21·87	K_2O	= 3·66
Fe_2O_3	= 5·38	Na_2O	= 1·00
FeO	= 6·24		
MnO	= 0·63		100·45

S.G. = 2·85 (Q.J.G.S. Vol. xxxiv. p. 224).

[2] Using for the occasion the old division into igneous and stratified.

tive. Again, in the case of metamorphic sedimentary rocks, we find one group which exhibits foliation very distinctly, another which does not. Now there is no name, so far as I am aware, for the rock in the latter group, which is the equivalent of gneiss in the former.[1] Again, unless we accept such a term as Hornblende rock (which I do not like), we have no name for the equivalent of Hornblende schist; and the same is true of other schists. Names like Hälleflinta, Hornstone, Lydian stone or Lydite, Porcellanite, want definitely fixing or deliberately leaving as indefinite—we have, in fact, no satisfactory nomenclature for the extensive group of compact felstone-like or flinty altered rocks.

In the case of the igneous rocks, also, several points require settlement. The limits of the terms Quartz-felsite (or Quartz-porphyry, a name I much dislike), Quartz-trachyte, and Rhyolite require fixing. We have to consider whether we ought or ought not to separate the microcrystalline from the cryptocrystalline Quartz-felsites, and then to decide what are the essential characteristics of a Quartz-trachyte, what are the limits of the name Rhyolite, and what view is to be taken of devitrified rhyolites. At present, as it seems to me, there is no line drawn between some Quartz-felsites and Quartz-trachytes, other than geologic age, which I for one do not think a safe basis for classification. Again, assuming that we take crystalline condition as the basis of subdivision in our groups, separated at first by mineral (or chemical) composition, the meaning of the term basalt requires fixing, and the groups of the nepheline and the leucite rocks are very unsettled. The same may be said of the "mica-traps," peridotites, and others, which, did space allow, it would be easy to name; but the above remarks may suffice to call attention to a real difficulty, which I imagine is widely felt by students of petrology.

St. John's College, Cambridge, T. G. Bonney.
November 20*th*, 1879.

DR. WAAGEN'S VIEWS ON THE GEOLOGY OF THE SALT RANGE IN INDIA.

Sir,—With reference to part of my letter in your September Number bearing upon Dr. Waagen's suppression of the Silurian group in the Indian Salt Range, I have since learned he has made the important admission: that for a time Stoliczka and himself were of opinion the fossils which I found in the *Obolus* group belonged to the Silurian period, and even now [May, 1879] he was "not prepared to maintain with certainty that that opinion was incorrect."[2] Notwithstanding this, in the case in point,[3] Dr. Waagen has not hesitated to condemn the classification adopted by me, although he elsewhere confessed himself uncertain of its being in error.

A. B. Wynne.

[1] I have proposed that of granitoidite, Q. J. G. S. vol. xxxv. p. 322.

[2] Neues Jahrbuch für Mineralogie, etc., 1879, "Ueber einige strittigen Punkte in der Geologie Indiens. Dr. W. Waagen. Wien, 1 Mai, 1879."

[3] Pal. Ind. Series xiii. Salt Range Fossils.

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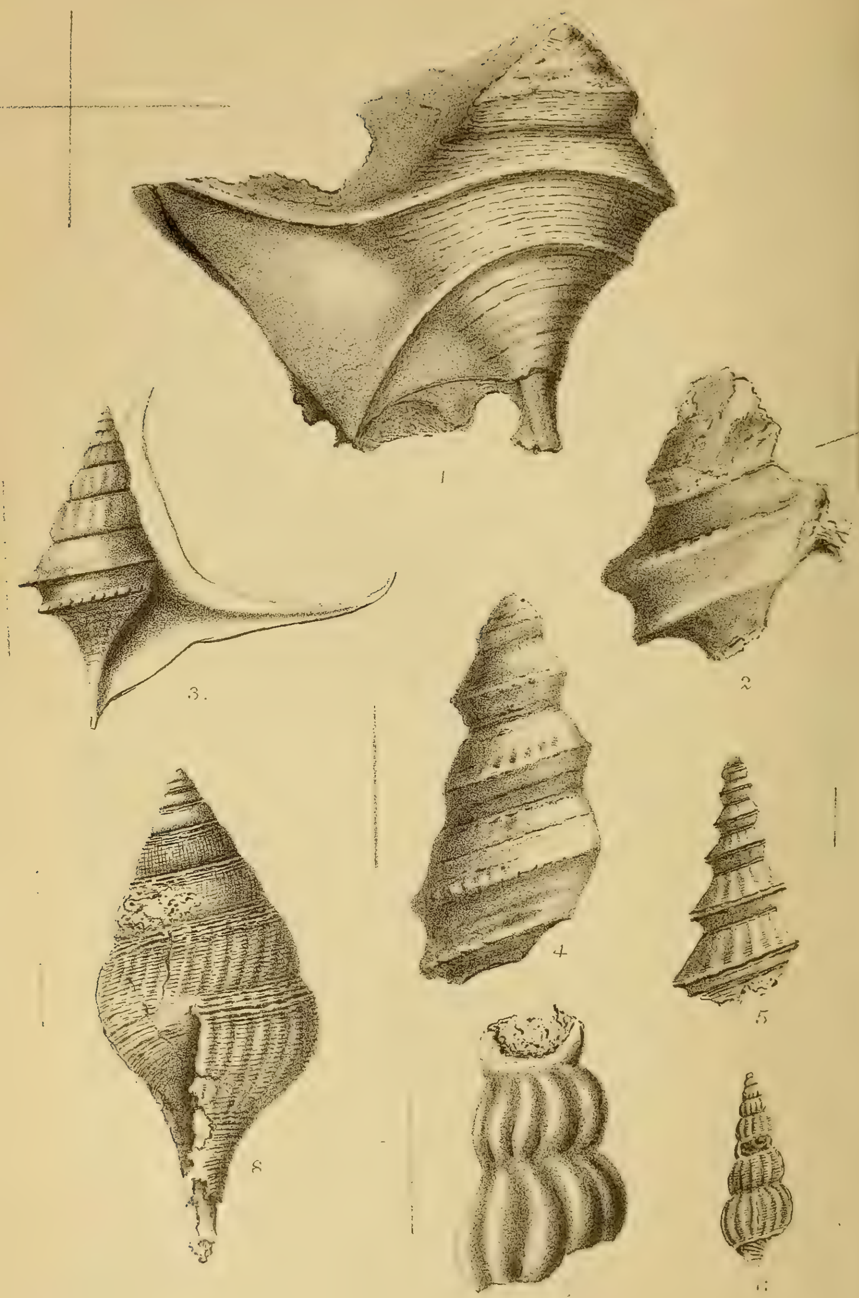

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No. II.—FEBRUARY, 1880.

ORIGINAL ARTICLES.

I.—Cretaceous Gasteropoda.

By J. Starkie Gardner, F.G.S., M.G.S. France.

(PLATE III.)

In September, 1875, Decade II. Vol. II. p. 394, of this Magazine, I was enabled, after having previously described them in detail,[1] to group all the known British Cretaceous *Aporrhaïdæ* together into four genera; and in March, 1876,[2] I added a fifth genus.

Mr. J. F. Walker, M.A., F.G.S., having kindly forwarded to me for description a few new Gasteropoda from Upware, including two *Aporrhaïdæ,* I now avail myself of the opportunity, in noticing them, to revise my previous work. Although collecting from the Gault and Grey Chalk of Folkestone (both of which deposits are very rich in species) has been incessant since 1875, no new forms have been found; and with the exception of those from Upware, none have been met with in any Cretaceous rocks in England.

The revision required is due, with a trifling exception, to the fact of my having overlooked certain genera established in America by MM. Conrad, Gabb, and Meek.

In the first place, I find it necessary to abandon the genus *Ornithopus.* A genus, *Tessarolax,* was established so long ago as 1864 by Gabb in the Palæontology of California, vol. i. p. 126, which he defined as follows:—

> Shell fusiform, spire and aperture about equal; spire incrusted by a thin deposit so as to obliterate the sutures. Body-whorl with two varix-like processes. Aperture broad above, continued below in a long curved canal; a posterior canal continues for some distance up the spire. Columella incrusted, without folds or teeth. Outer lip possessing two spine-like canals.

This embraces substantially all the characters of *Ornithopus,* with the addition of the varix-like processes and thin incrustation of the spire. These, however, can hardly be considered characters of sufficient importance, to render a separate genus desirable for shells not possessing them. In 1868, indeed, Gabb seems to have been of this opinion, for he modified the generic characters, and claimed *Pterocera bicarinata,* D'Orb., as a typical species. Yet in 1869[3] he appears to have again changed his mind, for we find two species almost identical with *P. bicarinata* of d'Orb. expressly excluded, and

[1] Geological Magazine, Decade II. Vol. II. pp. 49, 124, 198, 291, 393.
[2] *Ibid,* Decade II. Vol. III. p. 160.
[3] Palæontology of California, vol. ii. p. 166.

described as *Helicaulax bicarinata* and *H. costata,* a new genus of his own, in which they appear to be incorrectly placed. It would be possible either to retain the genus *Ornithopus* by limiting *Tessarolax* of Gabb strictly to the incrusted and tuberculated forms, which would practically make it obsolete; or to make the latter embrace *Ornithopus* by omitting the tuberculation and incrustation of the whole spire as generic characters.

Upon consideration, I think the simpler way, and the one most likely to be accepted unanimously by palæontologists, is to abandon *Ornithopus* and adopt *Tessarolax* in the wider sense, two separate genera being clearly unnecessary. I therefore adopt *Tessarolax,* according to Gabb's second definition, omitting as generic characters the presence of tubercles and complete incrustation of the spire, which are only rarely and abnormally present.

Tessarolax, Gabb. (American Journal of Conchology, 1868.)

Shell subfusiform, spire and aperture about equal; part of, or the entire spire and body-whorl incrusted by an extension of the inner lip of the adult: anterior canal long, curved or straight; posterior canal long, running up the spire, and extending considerably beyond it; outer lip expanded, generally carrying two long, slender, digitate processes. Whorls 5 to 6, always striated and bicarinated, without transverse ribs. Angle $37\frac{1}{2}°$ to 40°. The incrustation of the adult shell very exceptionally forms tubercles on the body-whorl.

This genus, to a slight extent, links the *Strombidæ* and *Aporrhaïdæ* together, but its affinities are with the latter.

Tessarolax, sp. nov. Pl. III. Fig. 2.

This fragment possesses all the characters of *Tessarolax,* and is similar in type to *T. retusa,* the small extent of the region of the body-whorl in front of the keels giving the shell a truncated, instead of a pear shape. The species was evidently finely striated, and the keels appear to have been slightly tuberculated, as in *T. Fittoni.* It was a larger shell than either of the Gault or Neocomian forms; but less than the Grey Chalk *T. oligochila.* It is scarcely sufficiently perfect to furnish specific characters. The unique specimen figured belongs to Mr. J. F. Walker, and is from Upware.

I have also figured (Fig. 1) a more perfect example of *T. oligochila,* Gard., from the Grey Chalk. This species proves to have possessed a more expanded wing than I was led to expect from the specimen first found, but it is never cut up into separate digits, as in most other species.

The genus *Tridactylus* remains unchanged, and has so far stood the test of time. Another species, sent to me by Mr. Walker, has to be added.

Tridactylus Walkeri, Gardner. Pl. III. Fig. 4.

Shell elongate and pupæform; whorls irregular, inflated, not forming a regular cone; possessing a strong central keel, a second and less prominent keel in front, and two partly concealed sutural keels. The body-whorl has two nearly equal keels (slightly diverging towards the outer lip, the front one being the less prominent), and three smaller keels, which are arranged above, below, and between, the primary keels. All the keels seem to have been tuberculated, and the spire was probably ribbed, as in *T. Griffithsii*, which it generally resembles. Length of fragment 22 mm., diameter of body-whorl 12 mm.

This unique fragment possesses great interest, since the only two Cretaceous species previously known were from the Gault. It is remarkable for the irregularity of its growth, the third whorl bulging to the left and the second to the right; this tendency perhaps preceded the more regularly pupæform shapes of the Gault species.

In the genus *Aporrhaïs* I had grouped some ten species, including all those which resemble existing *Aporrhaïs* or the Oolitic *Alaria* in general form. I referred them all to *Aporrhaïs*, believing the principal character upon which *Alaria* had been founded was not constant in the living species. I find that although this is the case, and to the greatest extent in the recent *A. pes-carbonis*, there is no such variation among the fossils, which differ further in the narrow produced wing and more elongated spire. I find it, however, inconvenient to place the very similar forms *A. marginata* and *A. carinata* in separate genera, as would be the case if any of the Gault forms were included in *Alaria* of Morris and Lycett, to which, especially as defined by Piette, they would perhaps strictly belong. Again, their facies differs considerably from that of the Jurassic forms, which have hitherto been almost the only ones accepted as referable to *Alaria*. It seems to me more simple to recognize *Alaria* as the Jurassic phase of the genus, and to group the Cretaceous phase in a separate sub-genus, for which the name *Anchura* has been proposed by Conrad, and generally recognized by American palæontologists. *Alaria*, which has been further restricted by Gabb, is characterized by him as follows:—

Shell fusiform, spire elevated; anterior canal more or less produced, straight or curved; without posterior canal; outer lip digitate, formed at one or more stages previous to the adult age, and left behind by the growth of the shell, producing varices or tubular spines; inner lip thin.

Sub-genus *Anchura*, Conrad (*Drepanocheilus*, Meek).

Shell fusiform, anterior canal straight, more or less produced; no posterior canal; outer lip produced into a single falcate process, generally if not always bearing a spur below, as well as above.

This sub-genus comprises the species of *Aporrhaïs* formerly placed in Group II. and a fragment, from Upware, which is evidently the remains of a shell closely allied to *A. carinella*, although with far more strongly tuberculated keels. It is doubtless a new form, but so fragmentary as hardly to deserve a specific name.

The species formerly placed in Group I. are still left in *Aporrhaïs* proper, for the sub-genus *Perissoptera* of Tate was founded to correspond more especially "with that section of *Aporrhaïs* which has *A. occidentalis* as its type,"[1] yet *A. marginata* (*P. Orbigniana*, Tate), which is included in it, approaches far more closely to the recent

[1] Geol. Repert. for September, 1865, p. 98.

A. pes-pelecani section. Much as I should like to adopt a distinctive generic name for the Cretaceous group, I fail to find any characters by which to separate them from *Aporrhaïs.*

Since I described the genus *Dimorphosoma*, the discovery of much more perfect specimens from the Grey Chalk at Dover has led me to remove one species, *D. opeatochila*, from that genus, and to place it, the only known British form, in the genus *Helicaulax* of Gabb. *Dimorphosoma* still remains by far the most distinct of all the genera, and embraces several American species.

Helicaulax, Gabb (American Journal of Conchology, 1868, p. 143).

Fusiform, anterior canal straight, more or less produced; posterior canal long, ascending the spire to near the apex, usually deflected near the extremity; outer lip produced in a single falcate process; inner lip usually heavily incrusted, the callus sometimes extending up the spire. The typical species is *H.* (*Rostellaria*) *ornata*, d'Orb.

Helicaulax opeatochila, Gard., Grey Chalk, Dover. Pl. III. Fig. 3.
syn. *Dimorphosoma opeatochila*, Gard., Geol. Mag. 1875, p. 399.

Shell small, length 23 mm.; spire elongated, angle 38°; whorls 8 or 9, moderately convex; sutures distinct; markings, about ten rather obliquely inclined finely striated ribs on each whorl of the spire; body-whorl with two angular and equal strongly tuberculated keels, below which are numerous tuberculated striæ; posterior canal same length as spire, attached to at least four whorls; apex free and pointed; outer lip expanded laterally in a single process, ending in a long awl-shaped digit; anterior canal short.

The figure is restored from several specimens. The species strongly resembles *H. ornata* of D'Orbigny, but is smaller in size, and has more salient keels, and less pronounced tubercles (see also Geol. Mag. 1875, Dec. II. Vol. II. Pl. VII. Fig. 9; and Pl. XII. Figs. 23 and 24).

It is found in the "cast bed" of the Grey Chalk near Dover, where it is by no means common. Specimens are usually very indistinct and broken.

Of the other American genera belonging to this family, I think we have a representative of *Pterocella*, Meek, in *A. macrostoma*, Sow., from Blackdown. There is, at all events, no other genus yet constituted in which this remarkable and unique fossil can be placed.

Pterocella, Meek.

Shell small, thin; whorls few, rounded, smooth or subangulated; last whorl not much enlarged; lip greatly extended and ascending the spire, trilobate, the middle lobe much larger and more produced than the others, carinated on the outer side.

The above generic characters, with but slight modification, would embrace the Blackdown shell.

The remaining Cretaceous genera, *Phyllocheilus*, Gabb, and *Calyptraphorus*, Conrad, appear to be more Eocene in aspect, and have no representatives in the European Cretaceous rocks.

The complete and revised list of British *Aporrhaïdæ* from the Cretaceous series is :—

Genus.	Species.	Neocomian.	Aptien.	Blackdown beds.	Gault.	Upper Greensand.	Chalk Marl.
TESSAROLAX	*Fittoni*, Forbes	x	.....	.....	.....	.....	.....
	globulata, Seeley	.....	.....	.....	.....	I	.....
	histochila, Gard.	.....	.....	.....	x	x	x ?
	Moreausiana, d'Orb.	x	.....	.....	.....	.....	.....
	oligochila, Gard.	.....	.....	.....	.....	.....	x
	pachysoma, Gard.	.....	.....	.....	.....	.....	I
	retusa, Sby.	.....	.....	x	x	.....	.....
	sp. n.	I	.....	.....	.....	.....	.....
TRIDACTYLUS	*cingulata*, P. & R.	.....	.....	.....	x	.....	.....
	Griffithsii, Gard.	.....	.....	.....	x	.....	.....
	Walkeri, Gard.	I	.....	.....	.....	.....	.....
APORRHAÏS, Group I.							
	glabra, Forbes	x	.....	.....	.....	.....	.....
	marginata, Sby.	.....	.....	.....	x	.....	.....
	Mantelli, Gard.	.....	.....	.....	.....	.....	x
	subtuberculata, Gard.	.....	.....	.....	.....	I	.....
	Parkinsoni, Mant.	.....	x	x	x	.....	.....
	Cunningtoni, Gard.	.....	.....	.....	.....	I	.....
	Robinaldina, D'Orb.	x	.....	.....	.....	.....	.....
APORRHAÏS, Group II.							
(ANCHURA)	*carinella*, P. & C.	.....	.....	.....	x	.....	.....
	carinata, Mant.	.....	.....	.....	x	.....	.....
	elongata, Sby.	.....	.....	.....	x	.....	.....
	maxima, Price	.....	.....	.....	I	.....	.....
DIMORPHOSOMA							
	ancylochila, Gard.	x	.....	.....	.....	.....	.....
	calcarata, Sby.	.....	.....	x	.....	.....	.....
	doratochila, Gard.	.....	.....	.....	x	.....	x ?
	kinclispira, Gard.	x	.....	.....	.....	.....	.....
	neglecta, Tate	.....	.....	x	.....	.....	.....
	pleurospira, Gard.	x	.....	.....	.....	.....	.....
	spathochila, Gard.	.....	.....	.....	.....	.....	I
	toxochila, Gard.	.....	.....	.....	x	.....	.....
	vectiana, Gard.	.....	x	.....	.....	.....	.....
HELICAULAX	*opeatochila*, Gard.	.....	.....	.....	.....	.....	x
PTEROCELLA	*macrostoma*, Sby.	.....	.....	I	.....	.....	.....
BRACHYSTOMA	*angularis*, Gard.	.....	.....	.....	I	.....	.....

I, indicates that but one or two specimens are known.
x, indicates that several specimens exist.

On Plate III. Fig. 8, is figured one of the young of *Aporrhaïs.* They are ribbed or reticulated fusiform shells, and all possess the apex smooth and obtuse; indeed, a smooth helicoid embryo is common to all the Gault *Aphorraïdæ.* These fry have hitherto figured as "*Fusus*, sp.," in all lists of Gault fossils. They are most abundant in the Gault at Folkestone, but with specimens less than half an inch long it is extremely difficult to distinguish the species.

In addition to the new forms of winged shells from Upware just noticed, Mr. Walker has forwarded to me a number of turbinated shells, in most perfect preservation, and of the greatest interest.

Although approaching somewhat closely to known Neocomian forms and to Blackdown forms, they appear to be distinct from them, and, so far as I can judge, new. Prof. W. Keeping is, however, engaged upon the Mollusca of Upware; and we have every reason to hope that the results of his studies will be shortly published, and that they will embrace descriptions of the shells here alluded to. Still, I cannot refrain from briefly noticing a very rare *Scalaria*, of which I believe no other specimen is known, and venturing to christen it in his honour. Another shell which particularly struck me was the internal cast of a rather large Calyptræa-like limpet, belonging to the Woodwardian Museum, which has spiral sutures, and in this respect is unique from British Cretaceous rocks.

Scalidæ.—*Scalaria Keepingi*, Gard., Plate III. Fig. 7.

Whorls inflated, about twice as wide as high; ribs 9 to each whorl, rounded, coarse, very irregular, flexuous; striæ very fine and barely perceptible under a glass; suture not visible.

This species, whilst resembling Neocomian forms, in other respects differs from them all both in the nearly complete absence of striæ and also by its concealed sutures.

The only fragment known is from Upware, and in the possession of Mr. Walker. It consists of nearly three whorls, and measures 19 mm.

I am also able to add a very beautiful species to the Gault list from Folkestone which differs only from *S. Dupiniana* in the form of its rib-like ornaments, which are sharper, more delicate, and more numerous, numbering 18 instead of 12; its more acute angle, 20°, and generally more delicate form, resembling in these respects one of the Blackdown species. A specimen of *S. Clementina*, Mich., has come to light, showing that this shell attained even greater dimensions than was supposed; measuring 11 cent. I have also received a new spiral Gasteropodous shell from Blackdown, which cannot be placed in any existing genus.

Disoketa,[1] gen. nov.

Shell turreted, whorls angulated, with two channels or grooves bordered by slightly elevated keels.

Disoketa Meyeri, sp. nov., Pl. III. Fig. 5.

Shell turriculated, in an angle of 20°; length 8 mm.; whorls 7 or 8, angulated except at the apex, the ridge or most salient point of each being considerably anterior to its centre, each ridge possessing a deep channel or groove sunk between two keels. A similar channel appears at the suture, and is disclosed on the last whorl as a second channeled keel. The flat parts of the whorls are undulated by wave-like ribs (at opposite angle to the spiral), which also influence the keels. The apical whorl is globose and ribbed; the body-whorl is somewhat produced on the right side.

This is perhaps one of the most unusual forms among Cretaceous shells. Such channels are only met with in a very few genera, and no equally turreted shell possesses them, except the Palæozoic genus

[1] δις, twice, οχετος, channeled.

Murchisonia, from which it is distinguished by the possession of the second channel. In the only living genus channeled in the same manner, the groove is known to result from a deep notch in the outer lip, and it is therefore likely that the aperture, which is not preserved, would have been found to be angulated and doubly notched.

In general form the shell very closely resembles the spire of *Anchura carinella*, even to the apical whorl and the slightly produced last whorl—but neither the cast nor the shell of the latter presents the slightest trace of grooves.

The specimen is unique, and I am indebted to Mr. Meÿer, to whom it belongs, for the opportunity of describing it.

While it is scarcely probable that many more species will be added to the Molluscan fauna of the Gault of Folkestone, where alone this formation has been systematically worked, the Blackdown fauna, from the number of unique and rare shells already obtained from it—a unique shell sometimes being the sole representative of a family—gives promise that it may still yield many more forms.

EXPLANATION OF PLATE III.

Fig. 1. *Tessarolax oligochila*, Gard., Colln. British Museum.
„ 2. *Tessarolax*, sp. nov., Colln. J. F. Walker, Esq., M.A., F.G.S., etc.
„ 3. *Helicaulax opeatochila*, Gard., Colln. British Museum.
„ 4. *Tridactylus Walkeri*, sp. nov., J. F. Walker, Esq., M.A., F.G.S., etc.
„ 5. *Disoketa Meÿeri*, Gard., gen. et sp. nov., Colln. C. J. A. Meÿer, Esq., F.G.S.
„ 6. *Scalaria*, sp. nov., Colln. British Museum.
„ 7. *Scalaria Keepingi*, sp. nov., Colln. J. F. Walker, Esq., M.A., F.G.S., etc.
„ 8. Fry of *Aporrhaïs*, Colln. British Museum.

II.—The Glacial Deposits of Cromer.

By Clement Reid, F.G.S.,
of H.M. Geological Survey of England and Wales.

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

TAKING into account the large number of papers that have been published on the Glacial Deposits near Cromer, any further description may appear unnecessary; and it was with this impression that I commenced the systematic examination of the coast three years ago. Before long, however, I found that in many important points the actual facts do not support the accepted theories of the origin of the deposits; and having now made a thorough examination, I lay the results before the reader.[1]

Literature of the Subject.—The first description of the contorted beds near Cromer was published in 1824 by R. C. Taylor.[2] In 1827 Taylor published three papers "On the Geology of East Norfolk," etc.[3] Mr. Samuel Woodward in 1833, in his "Geology of Norfolk," gave a long description and sections of the Cromer cliffs. The next was by Lyell, in the same year, in the first edition of his "Principles," and in 1840 he gave a still fuller account.[4] No description either

[1] This paper was read before the Geological Society, but only published in abstract.
[2] Phil. Mag. vol. lxiii. p. 81.
[3] *Ibid.* 2nd ser. vol. i. pp. 277, 346, 426.
[4] *Ibid.* 3rd ser. vol. xvi. p. 345.

before or since has, I think, equalled this for the clearness and accuracy with which the facts are noted. The various editions of Lyell's works all contain essentially the same account of the Cromer Till and Contorted Drift. In 1845 Joshua Trimmer published a paper in the Geological Society's Journal, and in 1851 he gave a further account of the beds, suggesting that the contortions had been formed by the melting of included masses of ice. In 1864 Mr. Gunn, in his "Sketch of the Geology of Norfolk," gave a description of the beds near Cromer. The Rev. O. Fisher, in 1868, published a paper in the Geological Magazine on the "Denudations of Norfolk." In the same year and Magazine Messrs. S. V. Wood, Jun., and F. W. Harmer, published an abstract of a paper, in which the Weybourn Sand is placed above the Pre-glacial freshwater beds, and made to pass by alternation into the Cromer Till. The succession given is—

	Sands and Gravels (Middle Glacial).
Lower Glacial	Contorted Drift.
	Sands on an eroded surface of Cromer Till passing, by interbedding, into Weybourn Sands.
	Forest Bed.

Messrs. Wood and Harmer in 1872 gave a fuller account of these beds in the Supplement to the Crag Mollusca.[1] In 1877 they brought forward the theory that extensive valley erosion had taken place after the formation of the Contorted Drift, and previous to the deposit of the Chalky Boulder-clay.[2] In the same year Mr. Belt published a paper, in which he apparently considers the "Contorted Drift" to be older than the first Boulder-clay, and to be a later stage of the Pre-glacial laminated loams.[3] The Rev. O. Fisher again suggests that the Boulder-clay passes under the "Forest Bed" of Happisburgh[4] [it is, however, merely a Pre-glacial stony soil, at first sight much like the bed below described as the "First Till"]. I have shown that, as Lyell originally pointed out, the Weybourn Crag comes below, and not above, the Pre-glacial freshwater beds, and that the Till is quite unconnected with these deposits.[5]

Pre-glacial Beds.—The Pre-glacial beds are too complicated to be described in a few lines: it will here be sufficient to state that the close of the Pliocene Period is marked by a lacustrine bed in which arctic plants, such as *Salix polaris* and *Betula nana,* occur for the first time.

Till.—For the examination of the Drifts the cliffs near Cromer are too much contorted and obscured by constant land-slips to be of much assistance; even inversions of the beds are not uncommon, and without great care they will convey an erroneous impression of the order of the deposits. It is therefore better to commence at Happisburgh, and work towards Cromer; for at Happisburgh the disturbances are not of such a nature or extent as to hide the relation of the beds.

The Pre-glacial beds are succeeded by a deposit of perfectly unstratified till, which rests on a planed and tolerably horizontal

[1] Palæontographical Society, vol. xxv. (issued for 1871.)
[2] Quart. Journ. Geol. Soc. vol. xxxiii. p. 74.
[3] Geol. Mag. Dec. II. Vol. IV. p. 156.
[4] *Ibid.* p. 479. [5] *Ibid.* p. 300.

surface of any of the older deposits. This "First Till" consists of a mixture of about equal parts of shelly sand and clay, with the addition of numerous striated pieces of hard chalk and oolites, and a smaller quantity of various Palæozoic rocks, granite, and trap of different kinds. The shells, though abundant, are certainly derivative, for they are usually sharply fractured, sometimes striated, and in the interior of one or two I have found the remains of a quite different matrix from that in which they are now imbedded.

The till was, I believe, formed by glaciers or an ice-sheet flowing partly over an old sea-bottom, from whence were derived the shells, and also the far-travelled stones. That this is the case seems to be proved by the fact that, besides the shells, several specimens of septaria and hard chalk, bored by annelids, and *subsequently striated,* have been dug out; this, I think, shows the agency of floating-ice, probably only coast-ice, which would bring stones from all parts, and scatter them on the sea-bottom, where they would be bored by the annelids, to be subsequently ploughed up and striated by the advance of the ice-sheet into the shallow water. It should not be forgotten, that though the first till is the earliest known bed which has been to any great extent accumulated by ice, the period immediately previous, when the arctic birch and willow flourished in England near the sea-level, must have been quite cold enough for the formation of coast-ice capable of bringing abundance of stones from Scotland and Scandinavia.

If we now try to discover the direction of the ice-flow, the absence of hard rocks under the till of course precludes any hope of finding striæ. Another test is, however, available, for where the ice has flowed over laminated clays, the beds have been crumpled slightly, just as a table-cloth is crumpled by the sliding of a heavy book. On clearing sections at Bacton I was able, by examining the direction of the folds, to find that the ice flowed from a point a little north of west, and the occurrence of abundance of the hard lower chalk also points in the same direction. The gathering ground appears, therefore, to have been on the chalk escarpment of Lincolnshire, which, if we take into account the enormous denudation it has suffered during the Glacial Period, must have been at that time much higher than at present. The ice flowed down the long dip-slope of the chalk till it reached the sea-level, and ground up the sand-banks, and a little of the underlying estuarine "Forest Bed," from which were derived the fragments of wood and bone and the green-coated Eocene flints which are sometimes found.

Next the ice would appear to have retreated, perhaps only for a few miles, leaving the Till with a curious hummocky surface, over which was deposited ripple-marked clay and marl in thin beds. This deposit, well shown between Hasbro' and Bacton, seems to be glacier-mud such as would flow from beneath the ice, and be evenly spread over the surface lately abandoned. I do not think that this evenly-bedded loam can be taken as sufficient evidence of an inter-glacial warm climate, though it is traceable nearly continuously for at least four miles, for at the present day the glaciers of the Alps and the ice of Greenland advance and retreat short distances without any very marked cause.[1] As yet no fossils are known from this horizon, so we are left in doubt as to whether it is marine or fresh-water, but the character of the deposit seems lacustrine.

Above these "intermediate beds" there occurs a second deposit of unstratified till, clearly distinguishable from the first till by the abundance of soft upper chalk that it contains. This bed is so like the Great Chalky Boulder-clay, that at Hasbro', where it caps the cliff, it has often been mistaken for that deposit, and it is quite possible that some of the Boulder-clays further south commonly referred to the Chalky Boulder-clay may, in fact, belong to the "Second Till."

Though this "Second Till" seems so different from the first, closer examination shows that this difference is more apparent than real, consisting only of a change in the relative proportion of the ingredients. The first till was above described as "a mixture of about equal parts of shelly sand and clay"; the second till is nearly half soft chalk and half clay, with a little shelly sand, the other materials being the same as in the older deposit.

At Hasbro' the intermediate beds under the second till are crumpled in the same manner as the pre-glacial beds; but from the difficulty of the examination, I have been unable to take the direction of the folding. There is, however, no reason for considering that the direction of the flow had changed, for the tills only differ in the shelly sand being replaced by chalk—a change accounted for on the supposition that the first advance of the ice ploughed out most of the sand-banks, leaving the second ice only bare chalk to grind up.

Though these tills are unstratified, they often show a "streak" like that of doughy bread or pie crust. This, I believe, has nothing to do with a sedimentary origin, but is simply formed like the flakes in pie crust by a sliding pressure from above. Special care is needed in the examination of Boulder-clays to avoid being misled by this appearance, for I have sometimes seen it so strongly developed as to be a fair example of slaty cleavage, though at first sight no one would have hesitated to point to it as evidence of ordinary bedding.

Sands.—Above the second till, and resting on an eroded surface of that deposit, or in one or two places on the Pliocene beds, there are fine false-bedded sands, always chalky and carbonaceous, and of a peculiar pale tint easily recognizable. At Mundesley these sands are about 40 feet thick, and they can be traced from Hasbro' to Trimmingham, but at the latter place they are lost. No fauna is yet known from them.

Contorted Drift.—Above the sands we find the irregularly stratified and more or less contorted deposit known as the Contorted Drift. This, I think, is most likely a true sedimentary Boulder-clay, though from the great difficulty of distinguishing between true bedding and "streak" produced by pressure, and also the fragmentary character of the shells, I cannot feel certain. In a few places it shows small contortions, such as might be formed by coast-ice, which appear not to

[1] Ordinary variations in temperature and in the rate of condensation from year to year, are fully sufficient to explain this well-known phenomenon.—Edit. Geol. Mag.

affect the overlying gravels, but all the more important contortions are of later date, as will be shown below. The lithological character is like that of the First Till, but the deposit is more sandy, and the bedding is conspicuous though irregular, as if the materials had been deposited in flattish heaps.

Sands.—Resting on this Boulder-clay we find beds of well-stratified sand and marl of undoubtedly sedimentary origin. These I have included in the Contorted Drift, though it is quite possible they may be the equivalents of the Middle Glacial near Yarmouth. The sands are nearly unfossiliferous, the only evidence of their marine origin as yet found between Cromer and Hasbro' being a single perfect valve of *Balanus*. West of Cromer, however, a patch of sand at Runton has yielded a fauna closely corresponding to that of the Middle Glacial, including among other species *Nucula Cobboldiæ*, an *Anomia*, and *Nassa reticosa*. This patch is unfortunately so violently twisted into the Contorted Drift that I cannot say whether it is the equivalent of the above sands or of the gravel next to be described.

Middle Glacial.—Above the Contorted Drift, and resting on a slightly eroded surface of that deposit, there are sands and gravels, often very coarse, like the "cannon-shot" gravels of Norwich. These are identified by Messrs. Wood and Harmer with the Middle Glacial, and in a paper to the Geological Society[1] they drew attention to the cliffs near Cromer as showing undoubted evidence of inter-glacial valley erosion. With regard to the correlation of these gravels with the Middle Glacial, I think this is a very doubtful point, for both by stratigraphical position and lithological character they will do at least equally well for the Cannon-shot gravels, which north of Norwich are intimately connected with and possibly replace part of the Chalky Boulder-clay.[2]

On the second point I am forced entirely to disagree with Messrs. Wood and Harmer; for, after spending upwards of two years on the coast, and also examining a large tract of country in the Waveney Valley, I cannot find the slightest trace of inter-glacial valley erosion. The basin-like hollows in which the gravels rest are clearly in every case the result of contortion and not of erosion, for the dip of the underlying beds is always conformable to the curve of the basin, however sharp it may be. There is a slightly eroded line at the junction, as mentioned above, but it has nothing to do with the basins. In the cliffs between Weybourn and Hasbro' there are about fifty of these scoops, all of which I have measured or sketched, and all show this general conformity in the underlying beds.

Age and Mode of Formation of the Contortions.—For more than two years I was quite unable to account for the peculiarity of the contortions in the Cromer cliffs. It was evident that they were later than the Middle Glacial, as that formation was also disturbed, and yet at the same time it was clear that contortions affecting the overlying beds were often much more complicated in the beds beneath, and also that many of the most violent contortions were

[1] Quart. Journ. Geol. Soc. vol. xxxiii. p. 78.

[2] See H. B. Woodward, Proc. Norwich Geol. Soc. vol. i. p. 58.

within a few inches of the smooth undisturbed surface of the Pre-glacial beds.

If we consider the generally accepted theory that the contortions were formed by floating-ice, it is evident that an iceberg ploughing up the sea-bottom must necessarily most disturb the highest beds, and the disturbance would die out gradually below and not end abruptly. To plane off such an even surface of the Pre-glacial beds the icebergs must be flat-bottomed and all submerged to the same extent. The ice must move quite steadily, not rocking, and must be of great thickness, or else it would at once pack.

In no part of the world can we point to floating-ice capable of forming disturbances equal to those seen at Trimmingham, and it should not be forgotten that there is no evidence at that period of a submergence sufficient to float thick ice, or of an open sea in which it could obtain the necessary momentum. The iceberg theory must therefore be abandoned.

What other explanation is then possible? Dr. Croll, in his "Climate and Time," has pointed out that at the period of maximum glaciation, that is to say, at the time of the Chalky Boulder-clay, the North Sea was entirely filled with ice, which flowed from a north-easterly direction over Norfolk. Before reading either Dr. Croll's or Dr. James Geikie's books, I thought it advisable to examine the coast, so as to form a quite independent judgment, and on comparing my observations lately with Dr. Croll's previously published views, I was greatly surprised at the close coincidence.

If the contortions are carefully examined, they clearly show that they were formed by a lateral thrust from N.E. or N.N.E., which on other grounds Dr. Croll gives as the direction of the flow.

But how can we account for the *detached* masses of chalk at the base of the contorted beds?

For many years the singular isolated character of the bluffs of chalk at Trimmingham has been accounted for on the various suppositions, that they formed islands in the Pliocene or Boulder-clay sea, or else of some Post-glacial disturbance, or lastly the Rev. O. Fisher,[1] among other explanations, suggests that "in attributing contortions in the underlying beds to the deposition of masses of matter upon their surface, I would go to the extent of suggesting that the remarkable bluffs of chalk at Trimmingham may have been upraised by some such action."

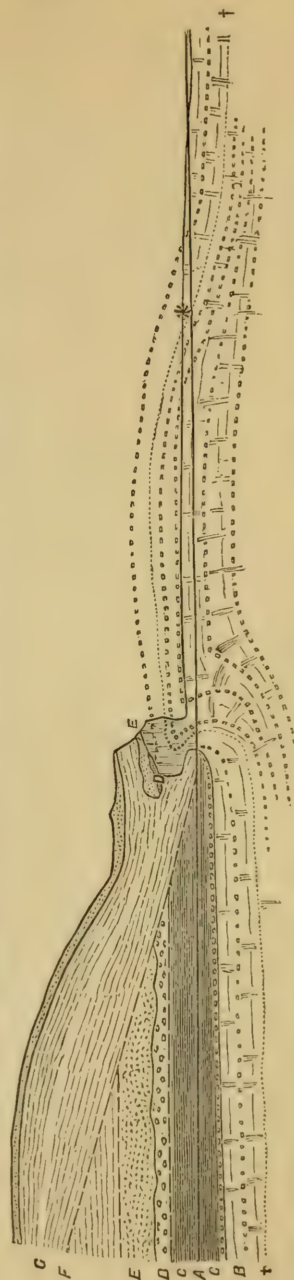
It has long been known that the lines of flint have been to a great extent affected by the disturbance, and two years ago, in measuring the westerly chalk mass, I discovered that they were folded into a complete loop, and also, as previously noted by Mr. Fisher, that the same beds were to be seen in the cliff and on the foreshore directly opposite. Fortunately a projecting point of the cliff enabled me to draw sections at right angles as well as in a line with the coast, and I saw that the direct action of an ice-sheet was the only way in which we could account for the extraordinary disturbance of the beds.

[1] Geol. Mag. 1868, Vol. V. p. 550.

A reference to the section will show that the contortion must have been caused by lateral pressure directly on-shore, that is to say, from the north-east; and that the disturbance, however caused, affected the whole thickness of the cliff, as Lyell first pointed out. The disturbance of the solid chalk extends to a distance of three-quarters of a mile along shore, and the thickness of the chalk and drift affected must, when we allow for denudation, be upwards of 300 feet.

If we now consider what an ice-sheet advancing over the North Sea could effect, we find that, after flowing over a tolerably level sea-bottom, it would at last abut against the rising land of the Norfolk coast. The ice would then drive before it a vast mound of the loose sands and Boulder-clays, exerting an enormous shearing force, so that the junction of the Contorted and of the Pre-glacial beds would be in reality a nearly horizontal 'fault-line.' This I think accounts, firstly for the undisturbed Pre-glacial or older Glacial beds beneath violently contorted beds, secondly for the sharp line of junction which can generally be fixed to an inch, and thirdly for the fact that the most complicated contortions are usually near the base, as the upper part would be merely thrown into a system of folds, while friction would cause the beds at the base to be full of small disturbances.

Fig. 1.—Section at right-angles to the cliff through the westerly chalk bluff at Trimmingham. (Scale 200 feet to the inch.)



A Level of low-water spring tides.
B Chalk, with sandy bed at +
C Pre-glacial laminated clays, etc.
D Second Till.
E Sands.
F Contorted Drift.
G The Beds in section *above white line* were seen and measured by the author.
* Chalk seen *in situ* on beach here.

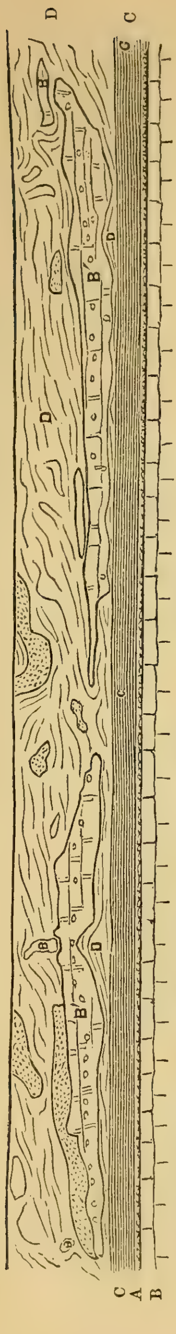


Fig. 2.—Cliff section west of Wood Hill, Runton. (Scale 150 feet to the inch.)

A Level of mean tides. B Chalk in place. B′ Chalk Boulders. C Undisturbed Pre-glacial Beds. D Boulder-clay with masses of sand.

It is very possible that at the time the contortions were being formed, the Pre-glacial beds were frozen into a tough sandstone, in which state, owing partly to the absence of joints, they would be more unyielding than the majority of ordinary rocks.

The shearing force or lateral pressure would not, however, act uniformly, for wherever there was a slight hitch the underlying beds would be ploughed up and contorted, as in the case of the Trimmingham Chalk. A little further pressure and the loop would be sheared completely off, driven up the gentle incline, and formed into a detached boulder such as we find at the base of the Boulder-clay near Runton (Fig. 2). That this is the right explanation of the mode of transport of the Chalk masses seems to be borne out by the fact that they always correspond in character to the chalk of the immediate neighbourhood, and that they disturb the overlying deposits, which would not be the case if they had been brought by icebergs. It is also singular that none of the transported masses are found beyond the district where the chalk is near the sea-level, and where it is occasionally ploughed into by the Boulder-clay. On the iceberg theory it is impossible to account for the non-occurrence of Chalk-boulders south of Trimmingham, and in the neighbourhood of Norwich and Yarmouth.

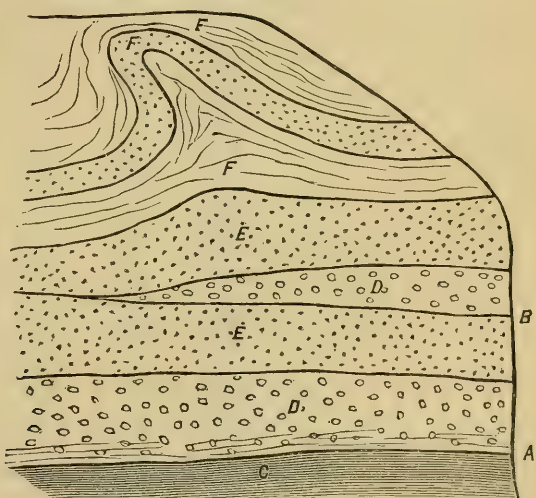
From the readiness with which they can be identified, the chalk masses have long been known; but it is evident that if the above explanation be correct, we ought also to find masses of the older boulder-clays and pre-glacial beds in the Contorted Drift. Such masses are to be found, though from their less striking contrast they are not so conspicuous.

On the west of Cromer, and close to the town, there is a transported mass of peat and laminated loams, just such as could be obtained from the top of the Woman Hithe or Runton black freshwater bed and the overlying *Leda Myalis* Bed. Of course I do not mean that it came from that locality, but that the beds are probably of that age.

South-east of Cromer, until the clue was obtained, I was constantly puzzled by finding masses that undoubtedly belonged to the Second Till and overlying sands, with what appeared to be evenly-bedded Boulder-clay like the Contorted Drift beneath them, the whole resting with a sharply-defined junction on the *Leda Myalis* Bed. The section taken at Sidestrand (Fig. 3) explains the difficulty, for there the sliding of the beds has undoubtedly caused the same succession to be repeated, the Second Till and Sands being shown twice in a vertical section without inversion. In this case the beds in the middle of the cliff are the most disturbed, for after sliding some distance along the plane A, it is evident that the line of shear was shifted to B, and while the lower part became stationary the upper part moved on, the beds sliding up the inclined plane. It is of course possible that the line B was the first formed, and as the ice thickened it planed deeper—but this would make no difference in the section.

Fig. 3.—Section at right-angles to the cliff near Sidestrand Church. (Scale 60 feet to the inch.)

A First line of fracture.
B Second „ „
C Pre-glacial Beds.
D D Second Till.
E E Sands.
F F Contorted Drift.



The laminated Boulder-clay just mentioned should be carefully examined, for when this is done it is seen to have no connexion with the undoubtedly stratified beds between the Tills, with which it appears always to have been correlated. The appearance of bedding is very deceptive, for in this case it is nothing but the effect of sliding pressure on the base of the moving mass, allied, as before suggested, to slaty cleavage, and quite unconnected with a sedimentary origin.

West of Cromer there is no trace of the Tills, except possibly as boulders in the Contorted beds. The whole of the glacial deposits appear to have been slid along in mass, and at the bottom of the moving mound a ground-moraine was formed equivalent in time to

N.E. S.W.

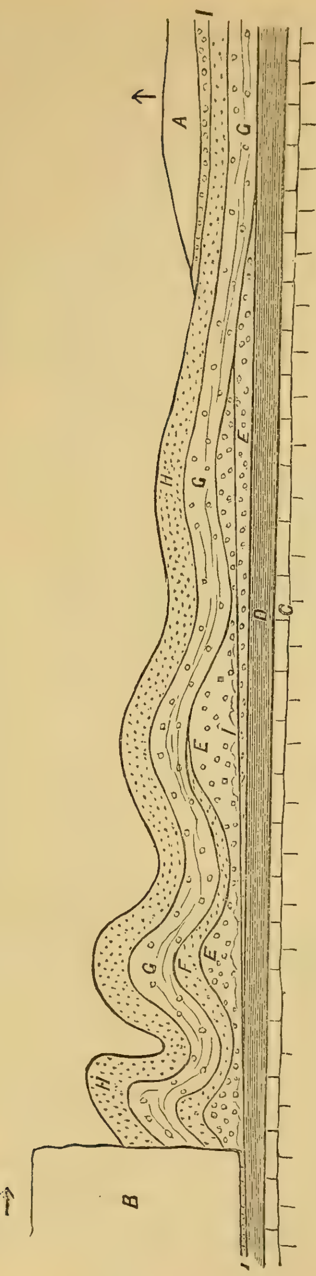


Fig. 4.—Diagram section to illustrate the mode of formation of the contortions.

A Ice from the north-west flowing parallel with the coast, and forming Chalky Boulder-clay I.
B Ice from the north-east, forming at its base Chalky Boulder-clay, and pushing forward a mass of the older beds, at the base of which a ground-moraine I′ is sometimes formed.
C Chalk. D Pre-glacial Beds. E Till. F Sands. G Contorted Drift. H Middle Glacial.

the Chalky Boulder-clay, but in lithological character much like the First Till, with which it has always been confounded. As we trace this bed north-westward it becomes more chalky, in fact so much so that it is difficult to distinguish from the Chalky Boulder-clay, into which it probably passes near Wells.

The diagram (Fig. 4) will give an idea of the relations and mode of occurrence of the different beds, but I am unable to offer any exact calculations as to the extent of lateral movement.

It is evident that the amount of vertical thickening of the beds gives the measure of their lateral compression and horizontal movement, so that a bed doubled in thickness is compressed into half its original extent, and if one end is stationary the other will have moved a distance equal to half the total breadth.

If we try to obtain some estimate of the probable extent of the lateral compression of the beds, we are at once met by the difficulty that the coast section runs nearly at right angles to the line of force, and we need sections along that line. However, by means of projecting points and of various stream channels we find that near Cromer the beds must have been about doubled in thickness, but the absence of inland sections prevents any further estimates being made.

Inland exposures of Contorted Drift.—If the explanation above advanced as to the date and mode of formation of the contortions be correct, it is evident that it ought also to account for the contorted beds near Norwich and in the Waveney Valley.

Before examining the coast section I mapped a considerable district in the Waveney Valley, on the borders of Norfolk and Suffolk. While engaged in this country I was constantly puzzled to find that where the Lower Boulder-clay was contorted, it was always directly overlaid by the Chalky Boulder-clay; but where uncontorted, the two were commonly separated by the undisturbed Middle Glacial Sands. If I am correct in referring the contortions to the age of the Great Chalky Boulder-clay, it is evident that this is just what we ought to expect; but on the theory that the contortions are contemporaneous with the bed, it is a most extraordinary coincidence. In the Norwich district, also, my colleague, Mr. H. B. Woodward, has found that all the large disturbances can be referred to the period of the Chalky Boulder-clay.

This, I think, will much simplify East Anglian geology, as it now appears that all the large disturbances are referable to one period—that of maximum glaciation, or of the Chalky Boulder-clay.[1]

Summary and General Conclusions.—The changes that have taken place since the close of the Pliocene epoch may be thus summed up, commencing at the oldest deposit:—

Arctic Freshwater Bed, with *Salix polaris*, *Betula nana*, etc.

First Till.—Advance of the ice descending from the chalk escarpment, and ploughing out sand-banks and marine boulder-clays of the Wash.

Intermediate Beds.—The ice recedes a few miles, and glacier-mud is deposited as ripple-marked loams and marls on the hummocky surface of the First Till.

Second Till.—Ice again advances, forming a second deposit of unstratified till.

Sands.—Submergence and formation of fine false-bedded sands.

Contorted Drift.—Strongly but irregularly bedded boulder-clay, probably sedimentary.

Bedded Sands and Marls.—Classed with the Contorted Drift.

Middle Glacial? Sands and gravels, resting on a slightly eroded surface of the Contorted Drift—not in valleys, as stated by Messrs. Wood and Harmer.

Chalky Boulder-clay.—Represented by the chalk and marl masses near Cromer, and by a ground-moraine sometimes formed at the base of the Contorted Beds. The large contortions are all of this date.

The period from the Chalky Boulder-clay to the present time seems also to be well represented in the Cromer Cliffs, but as the later glaciations did not extend so far south, the Boulder-clays of

[1] See also, with regard to the similar large disturbances in the Island of Moen, now proved to be of Glacial origin, Johnstrup, in Zeitschrift der Deutschen Geol. Gesellschaft, 1874, p. 533.

the north of England appear in this district to be replaced by valley deposits of various kinds.

The present features of East Norfolk have been, I think, in the main produced by the deepening of irregularities left on the disappearance of the great ice-sheet. The mound of Contorted beds pushed up by the ice still remains and forms the high land near Cromer. Valleys have been cut out of it, and the tops of the contortions planed off, but it still forms an important feature in the physical geography of Norfolk.

I have been quite unable to find any trace of the inter-glacial valley erosion mentioned by Messrs. Wood and Harmer. Where the Middle Glacial descends into the valleys, it is the result of contortion, and not of erosion, and it is difficult to understand how a Post-Glacial valley could coincide with an Inter-Glacial one, cut through soft beds, and which had been filled up and must be again excavated. If a valley happens to cut through a number of contortions, synclinals will occasionally bring the gravel to the bottom; but where an anticlinal is cut, the gravel is not to be found, and it is then said that it has been all scoured out of the valley.

III.—Mr. Hill on the Cause of the Glacial Epoch.

By James Croll, LL.D., F.R.S.

I HAVE just read Mr. Hill's criticism on my views as to the cause of the Glacial Epoch, and have to thank him for the fair and courteous way in which he has treated the subject. I fear Mr. Hill has come to his conclusions somewhat too hastily. He appears to me to have totally misapprehended the real effect of fogs and a snow-covered surface on climate, and also the influence of eccentricity on the trade-winds. But I must defer for the present entering into any discussion on the matter. My object just now is simply to direct attention to an erroneous assumption which appears to lie at the base of nearly all the objections which have been urged against the theory that the Glacial Epoch resulted from an increase of eccentricity.

It is assumed that when the eccentricity was at a high value, and the summer in perihelion, more snow must have been melted than at present. It is assumed that the quantity of snow melted must be proportional to the heat received from the sun. Suppose that on a certain area a given amount of snow falls annually. The amount of heat received from the sun per annum is computed, and after the usual deduction for that cut off by the atmosphere has been made, if it be found that the quantity remaining is far more than sufficient to melt the snow, it is then assumed that the snow must be melted, and that an accumulation of snow and ice year by year in this area is impossible. To one approaching this perplexing subject for the first time such an assumption looks very plausible, but nevertheless it is one totally opposed to known facts. Take, for example, Greenland. We know that that area receives from the sun per annum more than fifty times the amount of heat required to melt all the snow and ice formed on it, and yet that country is buried under ice. The annual precipitation on Greenland in the form of snow and rain, according to Dr. Rink, amounts to only 12 inches, and two inches of this he considers is never melted, but is carried away in the form of icebergs. The quantity of heat received at the equator from sun-rise to sunset, if none were cut off by the atmosphere, would melt 3⅓ inches of ice, or 100 feet a year. The quantity received between latitude 60° and 80°, which is that of Greenland, is, according to Meech, one-half that received at the equator. The heat received by Greenland from the sun, if none were cut off by the atmosphere, would therefore melt 50 feet of ice per annum, or 50 times the amount of snow which falls on that continent. What then cuts off the 98 per cent. of the sun's heat? Is it clouds and fog? If so, why do not these, according to Mr. Hill's theory, supply sufficient heat to melt the small quantity of snow which falls on Greenland? And if the heat is not cut off, and far more than sufficient to melt the ice reaches the ground, why is not the ice melted?

Take another example. South Georgia in the latitude of England is covered with snow and ice down almost to the sea-shore during the whole summer, and yet the amount of heat which that island receives is sufficient to melt 62 feet of ice. Why then are not the snow and ice melted? Suppose the snowfall there were ten times greater than that of Greenland, which it evidently is not, yet this would not amount to one-sixth part of what the sun's heat could melt. What then cuts off the 80 per cent. of the sun's heat? It cannot, according to Mr. Hill, be either clouds or fogs, and if the heat is not cut off, the question returns, why are not the snow and ice melted? There is still another thing to be explained. The snow falls in that region in the very middle of summer, but snow would not fall unless the temperature was near the freezing-point. Why then have we such a low midsummer temperature, notwithstanding the fact that the sun is in perihelion at that season?

There is another class of facts utterly at variance with Mr. Hill's fundamental proposition. The lofty peaks of the Himalayas, the Andes, and other mountain ranges are covered with perpetual snow. There comparatively few of the sun's rays are cut off, and yet the snow is perennial. Few, I suppose, would admit that at these great elevations more than 50 per cent. of the sun's heat could be cut off. But if 50 per cent. reached the snow, this would be sufficient to melt 50 feet of ice, and this no doubt is more than ten times the quantity which actually requires to be melted. Why then does not the heat melt the snow?

I have little doubt that if Mr. Hill will ponder over the subject, so as to find out a satisfactory answer to the foregoing queries, he will satisfy himself that the causes to which I attribute the Glacial Epoch are not so impotent as he has been led to suppose.

IV.—On Linnarsson's Recent Discoveries in Swedish Geology.

By Charles Lapworth, F.G.S., etc.

(PART II.)

(*Continued from p.* 37.)

On the Graptolites of Gothland (Om Gotlands Graptolither). By G. Linnarsson. Ofv. af. Kongl. Vetens. Akad. Förh.; 1879, No. 5, pp. 12.

The island of Gothland, so rich in all other Silurian fossils, is remarkably poor in Graptolites. Angelin and Lindström simply noted the fact of their presence, but did not attempt their identification. At Dr. Lindström's suggestion, Mr. G. Linnarsson here describes and figures the two species that have been procured from these strata, from examples now in the Riks-Musei of Stockholm.

The commoner form in the Gothland beds is the familiar species *Monograptus priodon*, Bronn. The author gives a careful description of this form, principally from the Gothland examples, which appear to be in a good state of preservation. He points out that, as in the examples from Dalarne, Westrogothia, and Britain, the polypary in this species is perfectly straight throughout, except near the proximal extremity, where it is slightly recurved. He admits, however, with characteristic candour, that this latter feature gives colour to Barrande's reference of the Bohemian sub-spiral forms to this species. I would here remark that the beautifully curved example figured by Barrande (Grapt. de Bohême, plate i. figs. 1, 2, 4, 5, 6, 7, 8, 9) is the only one of those placed by him under *M. priodon*, which agrees strictly with our British species in the form and relations of the thecæ. The examples illustrated in his figures 2, and 10 to 14, if they are correctly figured (and no one who has honestly studied Barrande's works can doubt this), cannot be *M. priodon*, as I understand it, but must belong to some species as yet undescribed. I have myself occasionally detected specimens not unlike Barrande's fig. 1, but they are excessively rare, and, like his, have the appearance of having been unnaturally distorted.

Linnarsson points out very correctly that *M. priodon* is, perhaps, more closely allied to *Monogr. lobiferus*, M'Coy, than to the typical form of *M. Halli*, Barr., near which I have referred it. The latter is, however, a most variable form, and many of our extreme British varieties have been generally referred to *Monogr. priodon*.

M. Ludensis, Murch., and *M. Clintonensis*, Hall, are placed by the author among the synonyms of *M. priodon*, but he is careful to note that in the present state of our knowledge they are most conveniently regarded as distinct. That their individual distinctness will eventually be placed beyond question appears to me to be quite clear. With regard to *M. Ludensis*, quoted by Murchison, from the Lower Ludlow beds of Siluria, neither Mr. Hopkinson nor myself, nor indeed any of the local geologists, have ever been able to detect a fragment of *M. priodon* in the Lower Ludlow rocks. A glance at Sowerby's drawing of the species in question (Siluria, plate xviii. fig. 1*a*), shows that it was made from a partly-decorticated specimen. His magnified drawing, fig. 1*a*, certainly gives the general impression that the thecæ were similar in form to those of *M. priodon*. But it is impossible to reconcile their appearance with that of the thecæ on the adult part of the polypary on fig. 1, which are like those of my *M. M'Coyii*. If the examples illustrated on fig. 2 are the same species, the question is settled, for these are wholly distinct from those of *M. priodon*. As regards *M. Clintonensis*, Hall, the differences are so marked that the question of identity may soon be disposed of. In *M. Clintonensis*, Hall, the polypary is slender; it has a ventral curvature; its proximal thecæ are those of the proximal end of *M. Sedgwicki*, Portk. (var. *Heuberni*, Geinitz); its distal thecæ alone resemble those of *M. priodon*, and they are wholly destitute of anything like overlap. In *M. priodon*, on the other hand, the polypary rapidly becomes stout and thick; it is either quite straight, or it has a dorsal curvature only; its proximal thecæ point in the direction of those of *M. lobiferus*, M'Coy; and in the adult thecæ there is invariably an amount of overlap, equal to at least half the length of the thecæ. Of course, the value of these criteria vary in the minds of palæontologists in direct proportion to their ideas of what amount of difference ought to separate allied species; but I would diffidently submit the opinion, that if these three forms had been *Trilobites*, Mr. Linnarsson would never have been aware of the possible existence of this difficulty.

The second form noticed is *Retiolites Geinitzianus*, Barr. This is also illustrated with several fine figures and described with great care. From a comparison of specimens collected, not only from Gothland, but also from the mainland of Sweden, and from Norway, the author finds the transverse section of the polypary to have been an oval, truncated at both ends. He is unable to detect anything like true partition-walls—the coarse filaments generally so called apparently forming an integral portion of the filiform framework. The appearances point rather in the direction of the theory that the whole interior of the polypary formed a single undivided chamber; a theory which, however, he does not advocate, as it is discordant with the opinions of those palæontologists who have already carefully examined the species. In a specimen in relief, from Norway, he finds a sub-median network, like that upon the exterior surface, traversing the body of the polypary longitudinally. There is no trace of a virgula in the Gothland specimen; but in examples from the mainland, a longitudinal fibre is frequently visible; but whether this is actually a true virgula, or whether, as Hall and myself have suggested, there are actually two of these median threads, one straight and the other zig-zag, there is in the Swedish specimens no evidence to show. The mouths of the thecæ are figured as octagonal, but there is no trace of ornamentation around their apertures.

These Graptolites are found in the strata of both of the two main divisions of the Gothland Silurian—the so-called Wisby Group and the Middle Gothland Group. *Retiolites Geinitzianus* has been detected by the author only in the Wisby Group; *Monograptus priodon* occurs in both formations.

On the Fauna of the Exsulans or Coronatus Limestone of Sweden (Om Faunen in Kalken med *Conocoryphe exsulans;* Coronatus-Kalken). By G. Linnarsson. pp. 28, 3 plates of figures. Stockholm, 1879.

At Kiviks Esperöd in Scania, where the horizontal Cambrian rocks are washed bare by the waters of the Baltic, Dr. Nathorst discovered, several years ago, a remarkable fossiliferous limestone undoubtedly belonging to the Primordial Zone of Barrande—containing a Trilobite-fauna, almost wholly new to science. In his description of the fauna of this limestone he enumerated *Paradoxides Tessini, Paradox. Hicksi, Solenopleura* and *Conocoryphe* (Geol. Fören. För. 1877, p. 264). The commonest fossil he referred to the Spanish species *Conocephalites coronatus* of Barrande and Verneuil, and gave the limestone the distinctive title of Coronatus-Limestone. It now appears, however, that Nathorst was in error in referring the Swedish fossil to *C. coronatus;* for according to Linnarsson the two forms are quite distinct. Nathorst's title for these beds is thus no longer suitable, and Linnarsson replaces it with the name *Exsulans* Limestone, after the new title he here assigns to the characteristic fossil.

At Kiviks Esperöd the Cambrian beds commence with the usual sandstones. These are overlaid by greywackes, undoubtedly belonging to the Zone of *Olenellus* (*Paradoxides*) *Kjerulfi.* These support a grey clay shale, underlying a band of nodular limestone. In the shales a few fossils are present—*Paradoxides* sp., *Conocoryphe Dalmani*, Ang., *Acrothele intermedia*, Linnrs. Next follows the so-called Coronatus-Limestone, which forms the subject of this paper. It is here a hard, grey, slightly bituminous limestone. Above it follows, after an insignificant hiatus, another limestone, the fossils of which allow us to parallel it without doubt with the well-known Andrarum-Limestone of Angelin, or the Zone of *Paradoxides Forchammeri* of Linnarsson.

Similar fossils to those present in the Coronatus Limestone of Kiviks Esperöd were detected in 1870 by Dr. Nathorst in loose stones near Sandby. At Gislof, where bedded Cambrians are visible, Herr von Schmalenzee, who completed the survey of Kiviks Esperöd, detected the fossils of the Coronatus zone in abundance. Finally, the same indefatigable investigator has discovered the same fauna in the classical locality of Andrarum, not only in loose blocks, but also *in sitû* from beds immediately below the strata of the zone of *Paradoxides Tessini.*

Linnarsson rightly points out that the fossils of the *Coronatus or Exsulans* Limestone are most distinctly allied to those of his zone of *Paradoxides Tessini:* but if we have regard to Schmalenzee's discovery at Andrarum, they may conveniently be regarded as marking a new horizon or sub-zone, immediately below it in the succession. The following are the commoner fossils of this new horizon :—

Paradoxides Tessini, Brongn.
——— *Hicksii*, Salt.
var. *palpebrosus.*
Liostracus aculeatus, Ang.
Solenopleura parva, n. sp.
Conocoryphe exsulans, n. sp.
= *C. coronatus* of Nathorst.
Conocoryphe Dalmani, Ang.
——— *tenuicincta*, n. sp.
——— *impressa*, n. sp.
Agnostus gibbus, Linnrs.
——— *fallax*, Linnrs.
——— *fissus*, Lundgr. MS.
Metoptoma Barrandei, n. sp.
Hyolithus, sp. ind.
Lingulella, sp. ind.
Acrothele intermedia, n. sp.
Obolella sagittalis, Salt.

Of the above species, at least four—*Paradox. Tessini, Liostr. aculeatus, Agnostus gibbus*, and *Agnostus fallax*—have been collected from the zone of *Paradoxides Tessini*, under its most typical aspect, not only in Scania, but in Westrogothia, Nerike and in Oland. On the other hand, not one has certainly been recognized in the zones of *Paradoxides Kjerulfi* and *Paradoxides Forchammeri*, which lie respectively above and below the zone of *Paradox. Tessini.*

The fossils of the Coronatus-Limestone are almost wholly peculiar to Scandinavia. A few of those figured by Barrande from his Etage C. are somewhat similar, but are not actually identical. As yet it is impossible to institute a comparison between the fauna of the Coronatus-beds and that of any of the presently accepted subdivisions of the British Cambrian, from the fact that, owing to the indifferent state of preservation of the British species, it is as yet impossible to say which of them are identical with the Swedish forms. From the general aspect of the fauna, however, it is suggested that the systematic place of the Coronatus-Limestone is between the Menevian and Longmynd Groups, as these are presently defined by Dr. Hicks.

The whole of the known species of the Coronatus-Limestone are described in full by the author, and illustrated in three very beautiful lithographic plates. Under his description of *Acrothele intermedia*, Linnarsson replies briefly to the strictures of Ford, more especially with reference to the implication that *Acrothele* was ignorantly founded upon the heterogeneous elements of the dorsal shell of *Lingula* and the operculum of *Hyolithus;* and points out extra-Swedish examples of his genus.

The strikingly Primordial character of the rich fauna of this previously overlooked Coronatus zone is apparent at a glance, and forms another of the abundant recent indications that the underrated Cambrian system, absorbed into the Silurian by the omnivorous Murchisonians and despised and rejected by the discontented followers of Sedgwick, is certain to prove itself as important in the geological series as the better understood, and therefore more highly estimated systems that succeeded it.

Like all Mr. Linnarsson's papers, this bears upon every page the marks of keen research and of modest caution, combined with deep palæontological knowledge, and it forms a most valuable contribution to the literature of the Cambrian rocks.

NOTICES OF MEMOIRS.

Address Delivered to the Norwich Geological Society by the retiring President, Mr. Horace B. Woodward, F.G.S., November 4th, 1879.

After referring to recent palæontological investigations that bear upon the geology of Norfolk, Mr. H. B. Woodward proceeded as follows :—

Leaving now the subject of organic remains, the collection of which possesses a peculiar charm in itself, I pass on to note a few points in physical geology, in the study of which it is not always easy to kindle and maintain an interest. This leads me into my own more particular branch of investigation, and opens up the question, often asked me during my rambles across country, "What is the use of the Geological Survey?" I shall not take up your time by attempting an elaborate answer to this. In each county geology may have different economic applications, and it is hardly a fair answer to tell the Norfolk agriculturist the value of maps and sections in mining districts, when he questions their practical value in his own county. My colleague, Mr. F. J. Bennett, has, however, lately taken up the subject, and in an essay read before the Ixworth Farmers' Club,[1] has called attention to the relations of the Geological Survey to agriculture. The object of the Survey is to portray on maps (the Ordnance Survey Sheets being used) the superficial distribution of the various strata or subsoils. In Norfolk these comprise Chalk, and several kinds of gravel, sand, loam, clay, and marl. Such deposits are classified according to their relative ages; and this is an essential point, because any one understanding their order of superposition, and mode of occurrence, can form a very good idea (from the geological map) of the strata likely to be met with in opening a pit or sinking a well. In short, the map is an index to the underground arrangement, and its applications in reference to economic deposits are at once apparent.

While brick-yards and lime-works mark the principal manufacturing industries connected with the geology of Norfolk, it is to its agricultural capabilities that the county is specially indebted. And in this respect, indeed, it stands almost unrivalled among English counties.[2] Hence it may be felt that it is with the soils, even more than with the subsoils or beds beneath, that a great part of the population is chiefly concerned; and at first sight the bearings of geology upon agriculture seem limited. Nevertheless, looked at in a large way, the rural economy of the country is directly influenced by the geology—partly from the character of the rocks themselves, partly from the physical features which have resulted from them. Thus the older rocks of the north and west of England, rising in rugged hills and mountains, with comparatively little soil, support a herbage suitable for sheep. The new red rocks, the Liassic and Oolitic clays, form pasture land, and upon them the dairy farms

[1] Published at Diss, 1879.

[2] Lincolnshire is said to stand pre-eminent.

abound. The Liassic and Oolitic limestones are largely devoted to cereals and green crops. The chalk areas, where bare of soil, are consigned to sheep-walks, while the Tertiary strata and drifts form rich agricultural districts.

When we look more particularly at the soils, we find a direct relation between them and the beds beneath. It has been spoken of as a sort of agricultural axiom, that the soil follows the contour. And when we remember that the strata over the chief agricultural districts in England are comparatively horizontal, that the valleys expose successive strata beneath, we can readily understand that as they follow the contour, the soils must be influenced by the subsoils. Indeed, if we take the classifications of soils made by agricultural writers, this is apparent. For the sake of example, we may take the general grouping adopted by Mr. C. S. Read, M.P. He divides Norfolk into five heads:—1. The chalk; 2. Blowing sand; 3. Stiffer soils; 4. Naturally good soils; 5. Diluvial soils. The Chalk is most conspicuous at the surface in West Norfolk. The blowing sand corresponds to the Glacial Sands, including the heath-land around Thetford, and that in the parishes of Horsford, Felthorpe, etc. The stiffer soils comprise the Chalky Boulder-clay of the country around Tivetshall, Long Stratton, Attleborough, etc. The naturally good soils, found chiefly to the north-east of Norwich, correspond to the Contorted Drift, and form the best land in the county, including that around Burlingham, Barton, Stalham, Bacton, and the Flegg Hundred. Then we have the diluvial tracts, including the fen land and the alluvial meadows of the river valleys. Thus we see that this division of soils corresponds to the larger grouping of the strata beneath.

After all, soils in most cases are merely the weathered surface of the subsoil, commingled with decayed vegetable and animal matter, and they vary in depth according to local circumstances, and according as the subsoil is suitable for worms, moles, and other burrowing and soil-forming animals. Frequently indeed the subsoil is ploughed up, and it is astonishing to see how often masses of Chalky Boulder-clay are turned over, appearing quite fresh, when one would have expected the calcareous matter to have been dissolved out. The Crag itself is occasionally ploughed up; and, in company with Mr. Sothern, I lately saw at Wroxham a furrow deeply eroded by rain, which exposed a bed of shells. Between Worstead and North Walsham the buff-coloured Glacial Sands are to be seen here and there in the ploughed fields, but in these, as in other cases, more particularly on the hill-slopes, where the soil is liable to be washed away.

In some cases it happens that the soil is of a boggy and peaty nature, or it may be formed chiefly from the relics of a deposit that once overspread the district, and which has been almost entirely removed by denudation. Such deposits may not be shown on geological maps; but from what has been said, the map will in all cases be a guide to the nature and capabilities of any tract of ground.

In reference to mining enterprise, geology has more often done good in preventing useless trials for "minerals" than in promoting explorations, and particularly in the matter of coal-boring, in which people seem most inclined to speculate. Black shale is generally enough to stimulate hope, and a man at Shottesham, probably from the testimony of the rocks in a Boulder-clay pit, told me he knew there was coal in the parish. Not a hundred years ago a trial for coal was made within five miles of Norwich. In his account of Framingham (1820), Dr. Rigby says, "There is a traditionary report, also, that even coal has been found here, and some years ago I was induced, in conjunction with the late James Crowe, Esq., who had some property in the neighbourhood, to dig to a considerable depth on a high part of what was then the heath. Near the surface was gravel, and below it clay, which continued until water rose and stopped our progress." He mentions the finding of "two isolated pieces of pure coal" in the clay; but these were probably lignite, being "of a texture very different" from the Newcastle coal. When called upon to give some answer concerning the likelihood of getting coal in Norfolk, I always reply in the affirmative, with these saving clauses, that a shaft be sunk deep enough, say one thousand or fifteen hundred feet, and that the speculator be fully prepared to find no coal.

As the question of the extension of Coal-measures beneath the Secondary and newer strata in England is one which concerns us, I will endeavour to point out the present state of the case. Supposing the chalk, which extends from Flamborough Head and Hunstanton to Salisbury Plain, were to be found now, as no doubt once upon a time it was found, still further west over Somersetshire, Gloucestershire, and the Midland Counties, we might then feel some difficulty and hesitation in sinking for Coal-measures beneath it, over areas where they are now exposed. We might make borings, and come across the Cambrian rocks at Charnwood Forest, the Silurian rocks near Dudley and at Tortworth, or the Old Red Sandstone on the Mendip Hills; and we might altogether miss the Coal-measures of Leicestershire, Warwickshire, South Staffordshire, Bristol, and Somerset. Much in this way have we been groping about in the east and south-east of England, where several borings have been made, which have reached these older rocks. Thus as you well know, in the deep well at Harwich, a dark bluish-grey slaty rock of Carboniferous age was met with at a depth of 1,029 feet beneath the Eocene beds and Chalk. At Kentish Town, beds belonging most probably to the Old Red Sandstone were reached at a depth of 1,114 feet; at Meux's Brewery in the Tottenham Court Road, London, Devonian rocks were met with at a depth of 1,064 feet; and at Crossness, near Blackwall, in Kent, strata classed as Old Red Sandstone, or Devonian, were touched at a depth of 1,004 feet. Further, in May of this year [1879], Mr. Etheridge announced the interesting fact that Silurian rocks (Wenlock shale) had been met with in a boring at Ware, in Hertfordshire, at a depth of only 800 feet below the surface. Moreover, a study of the rocks in Belgium and the north of France reveals the fact that Coal-measures are found sometimes at depths of only 300 or 400 feet beneath the Chalk and Tertiary strata. And here they are accompanied, seemingly in perfect conformity, by Devonian rocks, like those found under London.

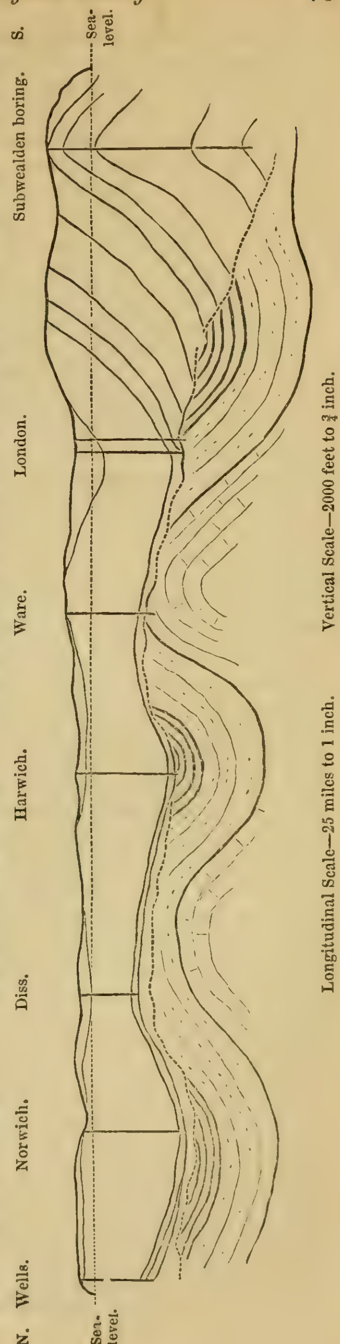
With these facts before us, there can be no question that there is great probability of productive Coal-measures being met with in the east of England. And we must give all honour to Mr. Godwin-Austen for having suggested this before any one of these borings had been made.

On the Continent the Palæozoic rocks are remarkably disturbed, and even inverted, thus presenting many features in common with the strata on the Mendip Hills. It is these disturbances which prevent any accurate calculations being made as to the probable position of the Coal-measures here or there, from the facts at present told by our deep borings.

Professor Prestwich, in his remarks on the Devonian rocks at Meux's brewery, was led to infer that Coal-measures might be met with to the north of a line drawn between Maidstone and London; but he added that "the Palæozoic strata are so disturbed and folded, that neither the dip nor the relative position of the Devonian beds afford any certain guide to the position of the Carboniferous trough."

Since these remarks were made, the Silurian rocks have been detected at Ware. That discovery may, however, in no way affect the matter, as in the Dudley Coal-field, the Wenlock beds rise up in proximity to the celebrated ten-yard seam of coal.

Concerning the slaty rock at Harwich, Professor Prestwich has



pointed out its resemblance to a bed in the neighbourhood of Mons, in Belgium, that attains a thickness of about 200 feet, reposing on the Carboniferous Limestone, and immediately underlying the Coal-measures. He was disposed to think that this rock at Harwich lay on the north side of a coal-basin, in which case the Lower Carboniferous and Devonian beds would rise beyond it and pass under Suffolk. Considering the disturbances before alluded to, we need by no means conclude that Coal-measures are likely to be absent from Norfolk; on the contrary, the undulations affecting the Palæozoic rocks are quite likely to bring in a coal-basin in some portion of this area. (See diagram, p. 75.)

Mr. Gunn, who has brought this subject before you on several occasions, has recommended a trial-boring to be made at Hunstanton. Of course, in West Norfolk, whether at Hunstanton, Lynn, or Downham Market, we avoid the Chalk, which we know to be over 1,000 feet at Norwich; but we do not know how thick the Oolitic strata may be in this district, and at Lynn the depth of 680 feet has been reached without passing through them. Whereas, in proceeding towards Harwich, we know that the Oolitic strata must gradually die out, for at this locality the Cretaceous beds rest directly upon the Palæozoic rocks. From these remarks it may be gathered that scientific opinion cannot ever do more than assert the *probability* of coal being met with here or there; and at present it can only assert the *possibility* of coal in Norfolk, without mentioning any one locality as more likely than another to yield it.

A very important application of geology is in the matter of water supply. Mr. Sutton has brought the subject before us, and he has pointed out that where water-bearing strata occur beneath an impervious bed, which would keep out all sewage contamination, there we have the most suitable conditions for a well. He stated that the best sources of domestic water in Norfolk are from the Chalk or from the porous sands resting on it, where these are overlaid by some deposit of clay. These "porous sands" are the beds known more familiarly to us as the Norwich Crag Series, including thereby not only the Upper and Lower Crags of Norwich, but the Bure Valley beds. This series is overlain to the north and north-east of Norwich by the Lower Glacial Brickearth; while south and west of Norwich it is extensively overlain by the Chalky Boulder-clay. Water is sometimes held up in this sandy series by one of the laminated clay beds, and where these are absent, the Chalk itself saturated with moisture holds up the water: or again it may be obtained at varying depths from fissures or cavities in the Chalk. Hence Norfolk has no cause to complain of its capabilities of yielding a water-supply, although no single well is likely to yield any very large amount. And it is to be hoped that some day Government will take up the subject, and insist upon good water being supplied to every dwelling in the land.

[After referring to the recent floods in Norwich, the President continued:—] A study of the present physical aspect of our land cannot fail to interest us. Who of us in wandering over the cultivated surface of Norfolk is not glad to find here and there, though very rarely, a tract of wild country that helps to lead back the imagination to those good old times when as yet the hand of Man had not materially altered the face of the country; when Nature, in fact, had it pretty much her own way. In thus looking back we are at once faced by the conclusion that Man is older than most of the present minor features of Norfolk. The deposits in which the earliest remains of Palæolithic man have been obtained, when he was associated with the Mammoth, Rhinoceros, Hippopotamus, Bison, Musk-sheep, Hyæna, and the old British Lion, are older than the present valleys in East Norfolk. For we find no records of any Palæolithic implements in the valley deposits of the Bure, the Wensum, the Yare, or the Waveney. The finding of an implement at Cringleford by Mr. Harmer is significant, but it is quite possible that the deposit in which this occurred, like that at Hoxne, in Suffolk, was cut through during the formation of the present valley. And this locality of Cringleford, together with that of Runton, are the only ones in the eastern half of Norfolk which have yielded Palæolithic implements. What the general aspect of the country was at this period of Man's early habitation, I cannot pretend to say; nor can I attempt to discuss the relations of the three divisions of Palæolithic man, which Mr. Skertchly has been led to establish from his observations in the west of Norfolk, and which are separated one from another by the periods of glaciation assigned to the great Chalky Boulder-clay, and to the Purple Boulder-clay of Yorkshire and North Lincolnshire. Great changes came about after these beds were formed. A large part of the country was submerged, as much as 1,300 feet in Wales, and subsequently re-elevated. Severe glacial conditions again desolated the northern tracts during the formation of the Hessle Boulder-clay. These gradually ameliorating, the climate became once more suitable for man, the present drainage system of Norfolk was established, and from this period we date the introduction of our modern fauna and flora.[1]

Then Britain was united to the Continent; the Chalk of Dover was not then separated from the main land, for, as Verstegan remarked in 1605, in speaking of the wolf, no man "would ever transport any of that race for the goodness of that breed, out of the continent into any Isles." And over this connecting area did the animals and plants migrate. Norfolk became a land of heath, woodland, and swamp, tenanted by the Wolf, Brown Bear, Reindeer, Irish Elk, and other Deer; by the long-fronted Ox or Celtic Shorthorn, the Urus, and the Beaver; and I may add, also, the Fresh-water Tortoise discovered at Wretham, and brought to our notice more recently from Mundesley. Since then Great Britain has been isolated from Ireland and the continent, and the coast of Norfolk has undoubtedly been encroached upon to an extent we can scarcely calculate—it may be two or three miles. Land has, however, been gained in our eastern valleys and in the Fenland. Beyond the widening and deepening of valleys, the actual surface of the country would not seem

[1] See J. Geikie, Great Ice Age, 2nd ed. p. 570 (table).

to have been greatly modified in feature, considering the many remains of Neolithic art scattered over the country; while the old flint workings called Grimes' Graves, near Brandon, still remain to tell of the Neolithic workers, considered by Mr. Skertchly to be the direct ancestors of the modern flint knappers, whose labours he has so lately described and illustrated. Even the pit dwellings of the early British or Iceni, described as occurring on the heaths of Weybourn, Marsham, Mousehold, and other places, remain as if to bear witness against any great subaerial denudation. But it must be borne in mind that in porous districts material is often removed by springs at the base of hills, and the general level lowered without the surface features being much altered.

Partly owing to its situation, but partly also to its agricultural capabilities, Norfolk was one of the earliest inclosed districts. The woodlands were effectually cleared, so that, not even in name, has any old forest been handed down to us, beyond what perhaps the derivation of such a word as Holt may indicate. The settlements became numerous—each inclosure or abode being marked by the names of places ending in -ham, -ton, -wick, -by, -stead, -field, -thorpe, -hall, -worth, etc., so that eventually a larger number of parishes was formed in Norfolk than in any other county.

Hence we may trace some connexion between geology and the modern aspect of each country. And for my own part I do not like to end the geological story at what is called the Prehistoric or Neolithic period, as if that marked any particular or world-wide change. Geological history, so far as we can read it, is a "story without an end." Our lives are wrapt up in it. Geology is continually teaching us the influence of the past on the present. And, setting aside the practical benefits, we learn that the truer benefits it bestows are in the influence its teachings have or ought to have on the happiness of mankind.

The account of a well-boring here, or the name of a fossil found there, are but the means by which we can realize geological history —the means by which the picture is painted.

In a novel we judge of the sequel according to the story in progress, we anticipate the ultimate triumph of good over evil. And in the evolution of the earth, while it may be difficult enough to see evidence of good design in every animated object, and in the evils to which all are subject, yet there is so much of beauty and harmony, that we need not spend our lives in lamenting over the evils and afflictions. Surely the diversified scenery, the infinite variety of plants and animals, of rocks and soils, and their adaptation to the wants of man, though they be the results of evolution, and of interaction of causes one upon the other, are not merely the wayward expression of natural forces, unthought of and disregarded.

And in our attempts to anticipate the sequel of geological history —seeing so much that is good and true and beautiful—we feel that the story can have but one end, that the more we learn of the great truths of Nature, the more do they compel our reverence and admiration, the more do they inspire our faith.

REVIEWS.

I.—A Manual of the Geology of India. Chiefly compiled from the Observations of the Geological Survey. By H. B. Medlicott, M.A., F.R.S., Superintendent, Geological Survey of India; and W. T. Blanford, A.R.S.M., F.R.S., Deputy-Superintendent. 2 vols. 8vo. pp. lxxx. and 817. Illustrated by 23 Plates, and a Geological Map. (Published by order of the Government of India: Calcutta, 1879.) London: Trübner & Co.

THE year 1879 forms an era in Asiatic Geology, as it witnessed the publication of the Manual of the Geology of India, a full and very able summary of the status of Geological Science in India up to 1878, written by Messrs. H. B. Medlicott and W. T. Blanford, the present heads of the Geological Survey Department. This Manual embodies the result of the Geological Survey, together with those springing from the labours of the, unfortunately very small, number of non-professional geologists who have made India their field of study, and sets them before the scientific world, clearly and systematically arranged, in two volumes, accompanied by a general geological map, the first of its kind, based upon a real survey.

The Manual is not offered to the public as a complete record of the Geology of India, as the Survey of the whole country is far from being finished; but, as the authors state in their preface, "It had become imperative as a duty to the public to bring together a summary of the work accomplished since the commencement of the Survey, and it was equally essential for the Survey itself that some general record of the results obtained up to date should be compiled. These objects could only be obtained by attempting a general map and review of the geology of India; but the reader must not forget that the present attempt is more of the nature of a progress report than of a finished work. The numerous and large areas left blank in the annexed map show at once how far the present publication falls short of the promise implied in the title."

Despite the admittedly imperfect character of the work, it is yet so rich in facts of the greatest interest to all true geologists, many of which are now for the first time made public in an easily accessible form, that it is right to draw the attention of the scientific world to the book. Unfortunately the limited length of this notice will not admit of full justice being done.

To begin with externals, the work is well got up, and the typography, like that of all the publications of the Geological Survey of India, is good, while the contents of the volumes are rendered easily accessible by the full tables of contents and general index; and non-geologists will be greatly helped by the glossary of technical and scientific terms used. The illustrations of the work consist of 21 well-lithographed plates of fossils, and of a few cuts of sections, fossils and views scattered through the text. A small sketch-map shows the courses of the principal mountain chains. The plates of fossils illustrate clearly the forms recognized by the Survey Palæontologists as leading types.

A noteworthy feature of the Manual is that the separate work of each of the two authors is made distinctly clear, the authorship of each chapter being stated. It will be seen from this that by far the larger share of the labour of drawing up the Manual fell to Mr. Blanford, whose great knowledge of Biology has enabled him to treat the subject in a far more interesting manner than would have been possible to a mere stratigraphist.

The weakest point of the Manual is the Geological Map of India given with it; but for this the authors can hardly be held responsible, as they had only to lay down the geological features on the best topographical map they could find: and, unfortunately, the best available is lamentably deficient in expression of the physical features of the country, there being no attempt at any representation of the mountains. That no good topographical map of India exists on which geologists might work is certainly to the discredit of the Topographical and Geographical Departments. The scale of geological colouring adopted is also unsatisfactory, being too pale, and too little contrasting, to impress the eye readily and favourably. The adoption of a livelier scale would be very advantageous for all the maps to be issued by the Indian Geological Department.

The interest of the Manual would also have been considerably enhanced if a larger number of sections had accompanied the text, for sections, even if only diagrammatic, add wonderfully to the facility of understanding and remembering geological facts and arguments.

To take up the text systematically, the preface explains briefly the plan of the work, the reasons for the double authorship, and the reasons for not giving a chapter on Economic Geology, which is promised as a separate work, and will, we trust, soon appear.

The introduction is a lengthy, but very interesting chapter, written by Mr. Blanford, which gives a capital *résumé* of the whole, including an outline of the physical geography of the country within the limits of the work, which coincide, roughly speaking, with those of the Indian Empire. This is followed by a list of the geological formations now recognized, of which ample tables are given. The remaining principal topics of consideration are a summary of the geological history of India, speculations on the origin of the Himalayan range, and the adjacent Indo-Gangetic plain (the two most strongly-contrasting physical features of Northern India), the distribution of the recent fauna, and questions of the affinities of Indian and Ethiopian mammals, the survival of older types in the Indian area, the Glacial epoch, and sub-recent changes of level.

The Introduction concludes with notices of previous summaries of Indian Geology, and some tables of the classification of European formations, and of the Animal Kingdom, which are given for comparison.

The remaining chapters of the Manual treat at length of the several geological formations in their principal areas of development, those of the Peninsular area being disposed of in the first volume, and those of the Extra-Peninsular in the second, the several formations being everywhere considered in ascending order. This division is based upon the very remarkable, but truly natural subdivision of India, on geological as well as geographical grounds, into two areas, divided from each other by the great alluvial spreads of the Indo-Gangetic plain, and styled, from their respective positions, the Peninsular and the Extra-Peninsular areas. This bipartite subdivision greatly simplifies the treatment of the geology of India as a whole.

The geological formations recognized differ as greatly in their character in the two great areas as do the physical features of the areas themselves. As the authors point out (Introduction, p. xi): "Throughout the Peninsular area, there is, from the lowest to the highest formation, a most remarkable deficiency of fossiliferous marine rocks; the few that occur being almost exclusively found in the neighbourhood of the present coast, or else in the deserts between the Arvali Chain and the River Indus. With one solitary instance, that of some Cretaceous beds occupying a limited area in the Narbada valley, no instance is known of marine fossils being found in the Indian Peninsula to the south-east of the Arvali range at a greater distance than 70 miles from the coast."

It is then shown that the absence of marine fossils is not due to the alteration of the strata, nor to the absence of rocks suitable to have preserved organic remains.

The oldest marine fossiliferous rocks in the Peninsular area are Jurassic, and these are well represented only in Cutch and the neighbouring countries. "The Cretaceous marine rocks are better represented; although a considerable portion of the series is wanting, and the area occupied is very small. The marine beds of the Tertiary period are also, so far as is known, very ill developed, or wanting, except in Guzerat and Cutch." *Per contra*, marine fossiliferous beds are not uncommon in the Extra-Peninsular area—representatives of the Silurian, Carboniferous, Triassic, Jurassic, Cretaceous, Eocene, and Miocene ages having been found, "and in many cases a complete sequence of the different subdivisions of each epoch has been detected; although far less time and labour have been devoted to the examination of the country than have been given to the Peninsula, and although the geology of the area is in general much more complicated, and the task of surveying surrounded by greater difficulties." (p. xii.)

As the Manual may very likely not come in the way of many of the readers of the Geological Magazine, it will be well to quote in full the classified lists of formations given by the authors, who themselves point out that "the great European subdivisions of the geological sequence—Palæozoic, Mesozoic and Tertiary, or Cænozoic—are ill adapted for the classification of the Indian beds: and in several instances, as will be shown more fully in other chapters of this work, the correlation of the strata found in the Peninsula of India with the geological series elsewhere is far from satisfactorily decided. The lower formations in this list are simply classed as Azoic. The subdivisions are not always strictly consecutive; some of the marine Cretaceous rocks being of the same age as the Deccan traps, and the marine Jurassic beds being contemporaneous with the Upper Gondwanas." (p. xii.)

"CLASSIFIED LIST OF FORMATIONS IN PENINSULAR INDIA."

				Approximate Maximum Thickness.
CÆNOZOIC.	RECENT AND POST-TERTIARY.		Blown Sand. Soils, including black soil or regur. Modern alluvial deposits of rivers, estuaries, and the sea-coast. Khâdar of Indo-Gangetic Plain, etc. Raised shell-beds of coast. Low-level laterite. Older alluvial deposits of Ganges, Narbada, Godâvari, etc. Cave deposits.	Unknown: 700 feet deepest boring.
	TERTIARY.		Miliolite of Kattywar. Pliocene, Miocene and Eocene (Nummulitic) beds of Cutch and Guzerat. Sandstones, clays, and lignites of the West Coast, Travancore, and Ratnagiri. Cuddalore sandstones. High-level laterite.	2,700
	DECCAN TRAP SERIES.		Upper traps and inter-trappeans of Bombay. Middle traps. Lower traps and inter-trappeans of Central India, Râjâmahendri, etc. Lameta or infra-trappean group. Infra-trappeans of Râjâmahendri.	6,000
MESOZOIC.	MARINE CRETACEOUS ROCKS.		Arialûr, Trichinopoly, and Utatûr groups. Bâgh beds. Neocomian of Cutch.	3,000
	MARINE JURASSIC ROCKS.		Umia, Katrol, Châri and Pachham groups of Cutch. Jesalmir limestones, Tripetty, and Ragavapuram beds of East Coast.	6,000
	GONDWÂNA SYSTEM.	*Upper.*	Cutch and Jabalpur. Râjmahâl and Mahâdeva.	11,000
PALC.?		*Lower.*	Panchet. Damúda:—Rânigan or Kâmthi, ironstone shales, and Barâkar. Karharbâri and Tâlchir.	13,000
AZOIC.	VINDHYAN SERIES.	*Upper.*	Bhânrer (Bundair). Rewah. Kaimur (Kymore).	12,000
		Lower.	Karnul, Bhima, Son. Semri.	2,000 ?
	TRANSITION OR SUB-METAMORPHIC ROCKS.	*Upper.*	Gwalior, Kadapah, and Kalâdgi Series.	20,000
		Lower.	Bijâwars. Châmpanir beds. Arvali. Malâni beds. Transition rocks of Behar and Shillong (the last extra-peninsular).	?
	METAMORPHIC OR GNEISSIC.		Gneiss, granitoid and schistose rocks, etc.	?

This full table is followed by another brief one, in which it is attempted to correlate the more important non-marine fossiliferous Peninsular rocks with their supposed marine representatives, and the latter with their European equivalents.

As the results of this correlation are very interesting, and probably very near the truth, this table is also reproduced. (See p. 85.)

[Note to Table reproduced on p. 83.] "The thickness of the different formations has only been determined in a few instances; so few that it is useless to quote them. The amounts are very great, the Tertiary rocks alone attaining a vertical development in places, as in Sind, of nearly 30,000 feet."

"CLASSIFIED LIST OF FORMATIONS IN EXTRA-PENINSULAR TERRITORIES BELONGING TO INDIA."

RECENT AND POST-TERTIARY.	Alluvial and lake deposits. Sub-Himalayan high-level gravels.*
PLIOCENE.	Upper Manchhars of Sind. Upper and Middle Siwaliks of Sub-Himalayas, Punjab, etc. Mammaliferous deposits of Western Tibet. Dehing group* of Assam. Fossil wood deposits of Pegu.
MIOCENE.	Lower Manchhars and Gâj of Sind. Murree beds* (in part). Náhan.* Tipam group of Assam ?* Pegu group of Burma.
EOCENE.	*Upper.* Nari group of Sind. Kusauli and Dagshai* groups of Sub-Himalayas. *Middle.* Nummulitic Limestone of Sind, Punjab, Assam, Burma, etc. Khirthar of Sind. Subâthu of Sub-Himalayas. Indus or Shingo beds of Western Tibet. Coal-measures of Assam ? *Lower.* Ranikot beds of Sind. Lower Nummulitics of Salt Range.
CRETACEOUS	*Upper.* Deccan Trap.* *Cardita Beaumonti* beds and Cretaceous Sandstones of Sind. Olive group of Punjab Salt Range. Disang group* of Assam. Upper Cretaceous of Khâsi Hills. Negrais beds of Burma. (N.B. It is not certain that some of these formations may not be, in part at least, Eocene.) *Middle.* Hippuritic Limestone of Sind. Cretaceous beds of Mount Sirban in Hazâra, and of Kohât. Chikkim beds of North-Western Himalayas. Cretaceous beds of Assam, in part. Mai-i group of Burma. *Lower, or Neocomian.* Beds in Chichâli Pass, Salt Range.
JURASSIC.	*Upper.* Salt Range, Gieumal and Spiti beds of Northern Punjab and North-Western Himalayas. *Middle.* Variegated group of Salt Range. Part of Spiti shales in North-Western Himalayas ? *Lower, or Lias.* Upper Tagling Limestone of North-Western Himalayas. Sylhet trap ?*
TRIASSIC.	*Upper, including Rhætic.* Lower Tagling Limestone of North-Western Himalayas. *Nerinæa* beds of Mount Sirban, Hazâra. Pâra Limestone of North-Western Himalayas. Beds with *Megalodon* and *Dicerocardium* at Mount Sirban, Hazâra. *Middle.* Salt Range ? Lilang series of North-Western Himalayas and Kashmir. Axial group of Burma ? *Lower.* Ceratite beds of Salt Range. Infra-Triassic* of Hazâra, in part ?
PERMIAN AND CARBONIFEROUS	Salt Range Carboniferous Limestone. Damúdas of Sikkim and Bhután ? Infra-Triassic* of Hazára ? Król Limestone* of Pir Panjál ? Król* Limestone and Infra-Król* of Western Himalayas ? Kuling series of North-Western Himalayas and Kashmir. Maulmain group of Burma.
SILURIAN.	*Obolus* beds of Salt Range. Attock Slates* of Upper Punjab ? Slates* and traps* of Pir Panjál and Kashmir ? Muth and Bhâbeh series of North-Western Himalayas. Blaini* and Infra-Blaini* of Simla area ?
INFRA-SILURIAN.	Salt-marl* of Salt Range. Gneiss* of Pir Panjál and Ladák. Upper Gneiss* of Zânskâr Range. Shillong series* of Assam Hills ? Mergui group ?* Lower or Central Gneiss* of Himalayas. Gneiss* of Assam and Burma.

DISTRIBUTION OF EXTRA-PENINSULAR FORMATIONS.

	SIND.	PUNJAB SALT RANGE.	NORTHERN PUNJAB.	N. W. HIMALAYA AND TIBET.	LOWER HIMALAYA & SUB HIMALAYA.	ASSAM.	BURMA.
PLIOCENE.	Manchhar	Siwalik	Siwalik	Mammaliferous beds	Siwalik.	Dehing Group *	Fossil Wood Group
MIOCENE.	Gaj		Murree beds*		Nahán *	Tipam Group *	Pegu Group.
EOCENE.	Nari				Kasauli and Dagshai *		
	Khirthar	Nummulitic	Nummulitic	Indus or Shingo [beds	Subáthu	Nummulitic and Coal-measures	Nummulitic.
	Ranikot	Lower Nummulitic	?				
CRETACEOUS.	Deccan Trap * Olive shales and sandstones	Olive Group	?			? Disang Group *	? Negrais group *
	Hippuritic limestone		Cretaceous of Mt. Sirban & Kohat	Chikkim beds		Cretaceous	Mai-i Group. *
		Neocomian					
JURASSIC, including LIAS.		Upper Jurassic	Upper Jurassic ?	Gieumal sandstone			
		Middle Jurassic (Kelloway)		Spiti shales			
				Upper Tagling limestone		Sylhet trap *	
TRIASSIC, including RHÆTIC.			*Nerinæa* beds	Tagling limestone			
			Upper Trias of Mount Sirban	Pára limestone			
		Middle Trias	? Infra Triassic and Tanol *	Liláng series.			Axial Group.
		Lower Trias		?	? Damudas		
CARBONIFEROUS.		Carboniferous limestone		Kuling series and Kiol limestone*	? Król * and Infra Król *		Maulmain Series.
SILURIAN.				Muth Series	? Blaini *		
		Obolus beds	? Attock slates *	Bhabeh Series	? Infra Blaini *		
INFRA-SILURIAN.		? Salt Marl	Metamorphic *	? Upper Gneiss		? Shillong Series	? Mergui Series.
				Lower or Central Gneiss *	Gneiss *	Gneiss *	Gneiss.*

		Peninsular Rocks.	*Supposed Marine Equivalents.* Indian.	*Supposed Marine Equivalents.* European.
CÆNOZOIC.		High-level laterite...	Nummulitic ...	Middle Eocene.
MESOZOIC.	Deccan traps.	Upper Deccan traps	?	Lower Eocene.
		Middle traps	Arialur	Upper Chalk.
		Lower traps	Trichinopoly ...	Lower Chalk.
		Infra-trappean or Lameta	Bâgh beds ...	
			Utatúr	Upper Greensand.
	Gondwána.	Jabalpur and Cutch Mahadeva and Rajmahal	Umia and Katrol ... ... Chári and Pachham... ...	Jurassic.
		Panchet		Triassic.
PALÆOZOIC		Damúda Tâlchir		Upper Palæozoic.

The geological horizons of the Tertiary and Upper Mesozoic beds may from this be assumed to have been very approximately determined, but considerable hesitation must yet be felt as to the real position of the Lower Gondwana formations, and "nothing is known of the age of the Vindhyan and older rocks."

The correlation with each other of the several formations found in different parts of the Extra-Peninsular area has been worked out to a lesser degree, partly because they are separated by countries inaccessible to Europeans, as Nepál and Affghanistan, and partly because some of the tracts they occur in are topographically less known.

Two tables of the Extra-Peninsular formations are given in the Manual, the first being a list of "the representatives of different geological horizons in various tracts," the second "an attempt to exhibit the probable correlation of the rocks in the different parts of the area, so far as the information available extends." Both these tables are here given, as they are of great value and interest. Where an asterisk is affixed to the name of a formation, it shows it to be unfossiliferous, and a note of interrogation that the position now assigned is doubtful. (See pp. 82–84.) R. B. F.

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

II.—Die Urzelle nebst dem Beweis dass Granit Gneiss Serpentin Talk, gewisse Sandsteine auch Basalt, endlich Meteorstein und Meteoreisen aus Pflanzen bestehen: die Entwicklungsgeschichte durch Thatsachen neu begruendet. By Dr. Otto Kahn. 8vo. pp. 71, and 30 Tab. (Tübingen, 1879.)

THE author on the title-page of this pamphlet affirms that he adds new facts in favour of the Evolution theory, since he pretends herein to prove that Granite, Gneiss, Serpentine, Talc, certain Sandstones, also Basalt, and finally Meteorites and Meteoric Iron, consist of Plants. In the preface he further claims to have settled all questions as to the origin of the earliest rocks, and specially of the older volcanic rocks.

In the following sketch of his views we will leave our readers to judge of the value of his statements, merely premising that inverted commas signify passages translated almost literally. He commences with the Eozoon question, on which he had previously expressed views opposed to its organic origin: his present opinion is that "the limestone of the Laurentian Gneiss of Canada, the oldest sedimentary beds of our Earth, contains a plant creation belonging to the family of the Algæ." He henceforward speaks of it as Eophyllum, and wonders that any one could have looked at Dr. Dawson's nature-printed figure "without thinking at once of a plant." He adds on his plates several figures, which he imagines prove the canal-system to be plants, while the sarcode chambers are plant-cells. Our readers, we fear, will need some key to these grotesque sketches, for from beginning to end we cannot see the faintest resemblance to anything in the vegetable kingdom, and certainly they do not help us to appreciate the wonderful position taken up in the text.

However, *Eophyllum canadense* is said to be allied to Fucus, to have a cup-shaped basal cell, which gives off buds or brood-cells. In a somewhat desultory sort of way the microscopic so-called Algæ are treated to the following names,—*Kampyloklon*, *Leucophyllum*,—of which the magnified views look like obscure dendrites, but the description of them is highly curious. *Pseudozoon* is a name now given to Carpenter's canal-system, which ranks as a separate plant. *Chairokerdos*, magnified 150 diameters, looks like a poor sort of dendrite, but much is made of it in the description; it is said to show spores, etc. *Poterion*, *Margarodes*, *Lichnon*, *Salpinœ*, *Kilikodendron*, *Pleurophyllum*, *Phiala*, *Theochara*, *Linophyton*, are made known to us by sketches without verbal descriptions—indeed, they seem indescribable; we almost fancy our author has been drawing the motes in his eye. In summing up results the earliest plant is described as a cell—"one cell fixes itself, the next grows upwards . . . . sometimes several cells are set one on the other . . . . next from these cells, generally at the border . . . . spring brood-cells (buds) in form of a leaf or cup; the cells divide—so the stem arises. . . . . As far as the forms of the cell are concerned, they are inexhaustibly different." We might add that they seem to vary as much in size, and we confess to a sort of curiosity to know the author's idea of a cell. Dr. Carpenter's nummuline layer is described as chrysolite fibres arranged round the surface of the brood-cells; and our author now fancies that all who worked at Eozoon and did not recognize this—himself included—"must have been stricken with blindness; . . . . every one who now examines the serpentine of the Eophyllum limestone . . . . where the plants are patent to the naked eye . . . . will strike his forehead and exclaim, How was it possible to miss seeing that!"

Having settled the oldest plant, we are introduced to the earliest animal, *Titanus Bismarki*, said to be something like a Serpula, but its tube to consist of numberless contractile rings. If we might hazard a guess, the author had a fragment of Helminth under his microscope here, but it is described as possibly "the forerunner of Trilobites."

This seems to finish what, from internal evidence, we may call the main object of the book; the remainder is rather discursive, both in matter and style. For instance, a letterweight of Saxony Serpentine was the cause of the next discovery. Bluish spots in it attracted attention; "how astonished was I to find in the greater part of it plant-forms 1 to 2 centimètres." The conclusion follows without further delay—"the greater part of Serpentines, particularly the Bohemian and Saxon, are nothing but Algæ beds." The plant which lived among this water-deposited Serpentine is called *Ophthalmia Hochstetteri.* Surely the eye affection has been here attributed to the wrong person.

But further wonders follow. The work was just closed for the second time when it was remembered that some Canadian rocks were still unpacked; to this happy memory we owe the discovery that "all the Laurentian Gneiss is nothing but a great plant deposit." "Most of these Algæ are visible to the naked eye." One is named *Dufferinia,* another *Victoria* (a botantical inadvertence), and another *Selvynia.*

Again the work was closed, and it was on the way to the press when the following train of thought occurred: "If Laurentian Gneiss is a mass of plants, why should not our Gneiss be so? And if our Gneiss is, why not Granite and Porphyry?" It was the work of a single night, but the result comes out as expected, "all Granite is nothing but plants, no stony matter in it, all plant; Mica and Hornblende are the calyx-cells, Felspar the substance of the plant. . . . Quartz forms mostly brood-cells. . . . Porphyry contains living plants . . . and is the detritus of primitive rocks." The plant in Garnet rock is called *Granatina Heeri.* That in Carrara marble, said to be a meter long, is named *Marmora Darwini.* Judging from the sketch it does not seem to consist of more than a score of so-called cells!

Then follow some petrological notions, we extract the following: "In the Polariscope the banding taken for Oligoclase are horizontal growth-stripes of cells. . . . Graphic Granite is felspar with wonderfully fine quartz-plants. . . . Basalts contain plants. What Zirkel calls Nephelinbasalt, are stem-cells of a plant, *Mycelium Zirkeli.* Fluidal structure is therefore Algæ cells. Olivine in basalts are plant cells . . . . most basalts are water products. . . . Leucite fills calyx-cells . . . . the dots in the small crystals are probably spores. Pitchstone is a plant-rock, and not volcanic. It is inconceivable that all this should have been overlooked till now." The above is verbatim.

The sedimentary origin of Granite, Gabbro, Felsite, and Basalt having been thus settled, the author was proceeding to press—he innocently again informs us—when he found some slices of meteoric stones among his collection. Guided by the set purpose of finding organic remains only, he had put aside as hopeless these meteorites, but finally he determines to examine them. The first one with much Olivine had apparent plant remains; the second, the Knyahinya fall, of 6th July, 1858, had undoubted plants—forthwith named *Urania Gulielmi.* Algæ, in another, were found in conjugation, and are termed *Heliola Caroli.* The Hainholz meteorite yields

Sphærothallium Swedenborgi. Next the Meteoric Iron of Toluca was examined, "it was plants, and nothing but plants;" the name *Astrosideron Quenstedti* is proposed for these. Again, "Pallas Iron, particularly remarkable—the Olivines are the calyx-cells, the iron-sulphide is the infilling substance, the dark iron is the wood (if the expression may be allowed), the white iron is the cell membrane of the plant," it is termed *Alexandrea.* Fearing lest this passage—which gives us some inkling of the author's idea of cell and plant—should be too much for our readers, we may perhaps spare them the remainder of his effusions. Of the state of the author's mind there cannot be much doubt, but it is indeed surprising that any publisher should have been found to issue such outrageous nonsense.

E. B. T.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—Dec. 17, 1879.—Henry Clifton Sorby, Esq., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "A Contribution to the Physical History of the Cretaceous Flints." By Surgeon-Major G. C. Wallich, M.D.

The author described the origin, the mode of formation, and the cause of the stratification of the Chalk flints. Taking as the basis of his conclusions the fact brought to notice by him in 1860—namely, that the whole of the Protozoan life at the sea-bed is strictly limited to the immediate surface-layer of the muddy deposits—he pointed out in detail the successive stages of the flint-formation, from the period when the chief portion of the silica of which they are composed was eliminated from the ocean-water by the deep-sea sponges, to the period when it became consolidated in layers or sheets conforming to the stratification of the Chalk. In relation to this subject the author claimed to have sustained the following conclusions:—1. That the silica of the flints is derived mainly from the sponge-beds and sponge-fields, which exist in immense profusion over the areas occupied by the Globigerine or calcareous "ooze." 2. That the deep-sea sponges, with their environment of protoplasmic matter, constitute by far the most important and essential factors in the production and stratification of the flints. 3. That, whereas nearly the whole of the carbonate of lime, derived partly from Foraminifera and other organisms that have lived and died at the bottom, and partly from such as have subsided to the bottom only after death, goes to build up the calcareous stratum, nearly the whole of the silica, whether derived from the deep-sea sponges or from surface Protozoa, goes to form the flints. 4. That the sponges are the only really important contributors to the flint-formation that live and die at the sea-bed. 5. That the flints are just as much an organic product as the Chalk itself. 6. That the stratification of the flint is the immediate result of all sessile Protozoan life being confined to the superficial layer of the muddy deposits. 7. That the substance which received the name of "*Bathybius,*" and was declared to be an independent living Moneron, is, in reality, sponge-protoplasm. 8. That no valid *lithological* distinction exists between the Chalk and the calcareous mud of the Atlantic; and *pro tanto*, therefore, the calcareous mud may be, and in all probability is, "a continuation of *the* Chalk-formation."

2. "Undescribed Fossil Carnivora from the Sivalik Hills, in the Collection of the British Museum." By P. N. Bose, Esq., B.Sc.

This communication contained descriptions of nine species of Carnivora from the ossiferous Sivaliks, together with an introduction, in which the age of the Sivalik fauna, and several matters of general interest, were briefly discussed. The species described were:—*Machærodus sivalensis*, *M. palæindicus*, *Felis grandicristata*, *Hyæna sivalensis*, *H. felina*, *Viverra Bakerii*, *Lutra palæindica*, *Canis curvipalatus*, and *C. Cautleyi*.

Canis curvipalatus is so named on account of the curvation of the palate. *C. Cautleyi* is closely allied to the Wolf, as is *Viverra Bakerii* to the Civet. The form of the forehead is peculiar in *Lutra palæindica*. In the form of the skull, the dimensions of the upper tubercular, etc., *Hyæna sivalensis* approximates to the living Indian Hyæna (*H. striata*); but, in the absence or extremely rudimentary character of the postero-internal cusp in the lower carnassial, as well as in the entire absence of the anterior accessory cusps in the upper and the first two lower premolars, the Sivalik species comes closer to *H. crocuta*. *H. felina* differs from all other species of Hyæna, living or extinct, in the absence of the upper premolar I. *Felis grandicristata*, which was of about the same size as some of the larger varieties of the Royal Tiger, had the sagittal crest even more prominent than the *F. cristata* of Falconer and Cautley. *Machærodus sivalensis* was of about the same size as the Jaguar. One of the specimens, on which this species is based, shows two molars in the deciduous dentition instead of three (as in the genus *Felis*). *M. palæindicus* was considerably larger than *M. sivalensis*. Both differ from all other known species of *Machærodus* in the form of the lower jaw, etc.

II.—January 7, 1880.—Henry Clifton Sorby, Esq., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Portland Rocks of England." By the Rev. J. F. Blake, M.A., F.G.S.

The author gave a general account of the relations of the several Portland rocks in the areas of their development to each other, and hence deduced the history of the Portland "episode." The name is used on the Continent in a wider sense than in England, and this use was shown to be unjustifiable. After giving an account of his observations on the rocks at Portland itself, and dividing the limestones into the building-stone and flinty series, the author showed that the so-called "Upper Portlandian" of Boulogne corresponds to the latter, and the upper part of the "Middle Portlandian" to the Portland Sand. He then endeavoured to prove by the proportionate thickness, the indications of change in the lithology, and the distribution of some of the fossils, that the rest of the so-called "Middle" and the "Lower Portlandian" are represented by integral portions of the Upper Kimmeridge, which are thus the "normal" form corresponding to what the author calls the "Boulognian episode." The series in the Vale of Wardour has been made out pretty completely. The Purbeck is separated by a band of clay from the Portland, and is not amalgamated with it. The building-stones and flinty series are here seen again; and a fine freestone occurs at the base of the latter. The representatives of the Portland sand were considered to be older than those of other districts.

The relations of the Purbeck to the Portland rocks at Swindon were very carefully traced; and it is shown that, while the upper beds of the latter put on here some peculiar characters, the former lie on their worn edges. The upper beds of the Portland, which have been referred to the sand, correspond to the freestone and the base of the flinty series of the Vale of Wardour; hence the Purbecks of Swindon may be coeval with the upper beds of the Portland to the south. At the base of the great quarry and elsewhere in the neighbourhood are the "*Trigonia*-beds;" beneath which is clay, hitherto mistaken for the Kimmeridge Clay; and beneath this are the true Portland Sands, with an abundant fauna new to England. The limestones of Oxfordshire and Bucks were considered to represent the "*Trigonia*-beds" only; and, as the Purbecks here lie for the most part conformably, it was suggested that they were formed in a lake at an earlier period than those at Swindon, which are of a more fluviatile character.

Hence the Portland episode, considered as marine, was at an end in the north before it was half completed in the south.

2. "On the Correlation of the Drift-deposits of the N.W. of England with those of the Midland and Eastern Counties." By D. Mackintosh, Esq., F.G.S.

The object of the author was not to dogmatize, but to present the subject in a concise form so as to stimulate to further research. His scheme of correlation was founded on the horizontal continuity of the deposits and their included erratics. He gave an account of his discovery of the continuous extension of the Upper Boulder-clay of Cheshire, above a great thickness of sand and gravel, as far as Berrington, south of Shrewsbury, and its appearance at intervals along the Severn valley to below Worcester, where it was probably represented by a bed with Malvern-hill boulders above shelly sand and gravel. He traced the great boulder-bearing clay and gravel around Wolverhampton eastward through Central England, to where it graduated into the chalky clay of Lincolnshire; and laid great stress on the commingling, at Wolverhampton, in this deposit, of erratics (chiefly granite and felstone) from the north with erratics (chiefly chalk-flints and gryphites) from the east. He described the clay and sand around Gainsborough, Retford, etc. He correlated the "carrion," or Lower Boulder-clay of the Vale of York (containing Carboniferous, Jurassic, and granitic erratics), with the lower yellowish-brown clay of the Aire and Wharfe valleys and the plain of Craven. He likewise correlated patches of upper clay in the latter areas with the Upper Boulder-clay of the Lancashire plain, but was not certain that they were of Hessle age. The solution of the main question depended chiefly on the relative age of the Wolverhampton and Stafford clay-and-gravel, which he was disposed to regard as the equivalent of the lower brown Boulder-clay of the N.W. and likewise of the chalky clay of Lincolnshire. He concluded by considering facts which might be regarded as opposed to this view, and by giving his reasons for regarding the palæontological evidence of the relative age of deposits as not, in all cases, reliable.

CORRESPONDENCE.

RECENT MOLLUSCA ON THE SIBERIAN TUNDRA.

Sir,—On the 14th January, 1878, Mr. Henry Seebohm read a paper before the Royal Geographical Society, on his visit to the valley of the Yenesei in 1877, and which was subsequently published in the Proceedings of the same Society. In his most interesting account of that region, the tundras are thus described. "The Siberian 'tundra' is something like the fjelds of Lappland, something like a Scotch moor or an Irish bog. It is a wild undulating extent of country, full of rivers, lakes, and swamps, stony, but not rocky, gay with brilliant wild flowers, abounding with ground fruits, such as crowberry, cranberry, cloudberry, and Arctic strawberry, and swarming with clouds of mosquitoes. The hill tops are barren and stony, but the valleys shelter dwarf willows and stunted birch.

"These 'tundras' are evidently rising gradually. Ancient drift wood, rotted into tinder, is often found above the present limit of the highest floods, and at Gol-cheek'-a (N. lat. 71° 30′ on the Yenesei), I found large heaps of recent sea-shells at least four miles from the river-bank, and 500 feet above the level of the sea."

Mr. Seebohm kindly permitted me to examine the specimens which he gathered from the position referred to, and with the aid of Mr. Edgar A. Smith, the following species were determined.

Mollusca.	*Pecten islandicus*, Chemn.
	Astarte borealis, Chemn.
	Natica affinis, Gmelin.
	Saxicava arctica, L.
	Fusus (*Neptunea*) *Kroyeri*, Möller.
	Fusus (*Neptunea*) *despectus*, L.
Cirripedia.	*Balanus porcatus* (Da Costa).

The recent elevation of the Siberian tundras is well known, and in the travels of M. de Middendorf and Von Wrangel frequent allusion is made to the subject. Mr. Henry H. Howorth, in a very interesting paper, published in the Journal of the Royal Geographical Society of London, 1873, has brought together and discussed an immense amount of information in regard to the recent elevations of the earth's surface in the northern circumpolar region, in which the tundras of Siberia come in for due share of notice, and makes it unnecessary for me to do more than refer to his paper.

The special interest of Mr. Seebohm's observation lies in the fact of the very great elevation, namely, 500 feet, at which he procured the specimens I have recorded, all of which are now existing and common in the neighbouring seas. H. W. Feilden.

THE PENNINE CHAIN.

Sir,—Will you allow me to say a word on the subject of the geological age of the Pennine Chain? Some five or six years ago I became aware of the fact that the Coal-measures in the neighbourhood of Nottingham have a fairly persistent north and south strike beneath the Permian rocks, and that some of the north and south faults in the Coal-measures do not affect the overlying rocks, at any rate to anything like the same extent. I immediately saw that these facts were sufficient to prove that the Carboniferous rocks had been subjected to a north and south series of disturbances before Permian times; and I concluded that since the Pennine axis follows the same direction it probably belongs to the same period. I mention this not for the purpose of claiming priority over my friend Mr. Wilson in this matter, but merely for the purpose of justifying my interference in the present discussion.

Now, Sir, I contend that the evidence of pre-Permian flexuring and faulting along north and south lines in this neighbourhood is quite sufficient to settle the question as to the date of the origin of the first movements in this direction.

I think both Mr. Wilson and Prof. Hull, in discussing this question, are a little hampered by the notion of anticlinal axes forming barriers. Thus, the greater portion of Prof. Hull's letter (Geol. Mag. Vol. VI. p. 573) is devoted to a consideration of the question of the similarity of deposits on opposite sides of the Pennine Chain, and this of course is strictly relevant to the discussion as raised by Mr. Wilson (Geol. Mag. Vol. VI. p. 500). It does not, however, affect the question of the date of the north and south movements, which is really the important question at issue. On this question, all the direct evidence I know of points to the conclusion that these disturbances originated during the immense interval of time which elapsed between the close of the Carboniferous period and the commencement of that portion of the Permian period which is represented by deposits forming the eastern boundary of the exposed portion of the Nottingham and Yorkshire Coal-basin.

I have read Prof. Hull's paper on this question, Q.J.G.S. vol. xxiv. p. 332, and, like Mr. Wilson, I fail to see that the evidence there adduced, in favour of the Post-Permian and Pre-Triassic date of the origin of these north and south disturbances, is of much value, even when standing by itself, and I consider that it is completely destroyed by the fact, mentioned above, that the Coal-measures strike north and south beneath the Permian rocks for some distance north of Nottingham. Prof. Hull seems to think that the physical discordance here referred to is slight, and supposes it to be due "to a sort of sympathetic movement which took place during the progress of the more powerful east and west flexuring at the close of the Carboniferous Period." I think the epithet "slight" is scarcely appropriate to a physical disturbance accompanied by denudation which determined the western boundary of the great Nottinghamshire and Yorkshire Coal-basin, and produced a north and south strike in the rocks which formed the crust of the earth during Permian times for many miles north of the place where Nottingham now stands.

I maintain, then, in the absence of any direct evidence to the contrary, that we are bound to conclude that the north and south series of disturbances, like the east and west series, originated at the close of the Carboniferous Period. I say nothing about the age of the Pennine Chain as a barrier of high land; for all I know to the contrary, the anticlinal may have been planed away before the Permian Period, and the Permian rocks deposited continuously across it. The discussion as to the correspondence of rocks on opposite sides of the axis will throw interesting light on this question.

I think the reason many geologists experience a difficulty in accepting the conclusion advocated in this letter is because they are still hampered by the fallacy that the Permian system is separated from the Trias by an important physical unconformability.

9, All Saints' Street, Nottingham. J. J. Harris Teall.

THE AGE OF THE PENNINE CHAIN.

Sir,—At the time when Prof. Hull ascribed the elevation of the Pennine Chain to the interval between the Permian and Trias, a great hiatus was supposed to occur between the deposits of those epochs in this country. Now, however, we have learnt to believe that the great stratigraphical break comes, not between the Permian and the Trias, but between the Carboniferous and the Permian formations. Nevertheless the faith in the older hypothesis seems to have created a bias on the question at issue that still lingers in the learned Professor's mind.

Prof. Hull only assails two of my arguments for a pre-Permian Pennine Chain; it is these only, then, that I have to substantiate.

The Yorkshire Coal-field was evidently completely formed anterior to the Permian epoch. The prevailing easterly dip of the Coal-measures of Derbyshire and Yorkshire is *appreciably greater* than that of the Permians. (The reason why this difference in dip is not more decided in the vicinity of the Magnesian Limestone escarpment is that we are thereabouts beginning to reach the more central and therefore flatter lying portions of the Coal-basin.)

The unconformable westerly overlap of the Coal-measures by the Permians, consequent on this greater dip, is, as illustrated in my paper,[1] decided enough. Prof. Hull is well aware of this; for in a paper "On a Deep Boring for Coal at South Scarle, Lincolnshire," we find him expressing the opinion "that the Coal-measures of the Yorkshire and Derbyshire Coal-field, after extending for some distance with an easterly dip beneath the Magnesian Limestone, rise to the eastward, and ultimately *terminate against the base of this formation.*"[2]

[1] Geol. Mag. November, 1879.

[2] Proc. Inst. Civil Engineers, vol. xlix. part iii.

Profs. Ramsay and Green take a similar view.[1] As Prof. Hull knows, rocks in all probability belonging to the *Upper* Coal-measures were reached at South Scarle directly beneath the Permians; whereas 25 miles further west in the Erewash Valley district the Magnesian Limestone and underlying Marl Slates repose on measures low down in the Middle Coal series.

Here, then, there is clear proof of an overlap of from 1,500 to 2,000 feet at the least. There must have been great meridional (as well as East and West) foldings of the rocks, followed by extensive and long-continued denudation, between the close of the Carboniferous and the commencement of the Permian epoch. As some results of these foldings (and this denudation), were synchronously developed the Yorkshire Coal-basin synclinal and the inseparably connected Pennine range anticlinal.

There is no similarity between the Permians on the opposite sides of the Pennine Chain. As the late Sir R. Murchison once remarked, "The most striking phenomenon in regard to the natural group (Permian) in Great Britain is *its very dissimilar lithological character* of the opposite sides of the central axis of the country. . . . ."[2]

I did not overlook the paper Prof. Hull refers to.[3] In the discussion that ensued, several eminent geologists disputed the view of there being any decided difference between the "Lower Permians of the Salopian" and of "the Lancastrian types." Be that as it may, it is quite another thing from the Permians of the North-east and North-west types agreeing. I failed then and I fail now to see any sufficiently close resemblance between these latter deposits to lead one to infer that they were continuously deposited. I am not personally acquainted with, and therefore did not express any opinion as to the age of the 1500 feet of unfossiliferous red sandstone in the neighbourhood of Stockport. Prof. Ramsay refers to the "lower red sandstones" of Lancashire as beds "generally believed to represent the Rothliegende," and as "so-called Rothliegende."[4] Such phrases seemed to me to indicate a certain amount of doubt as to their identification. In the absence of fossils, mineral character will not suffice to identify these deposits as Lower Permian. Neither will their unconformability to Coal-measures. In Yorkshire the Rotherham Red Rock rests with a marked unconformity on Coal-measures, but is now rightly classed by the Government surveyors as belonging thereto. So many red rocks in the North of England, and elsewhere, once termed "Rothliegende," have been since shown to belong to some member or other of the Carboniferous formation—whilst others are as certainly Triassic—that geologists are advisedly cautious in dealing with any so-called rock. Let us assume, however, that in Lancashire a deposit of red sandstone attaining four or five, if not fifteen hundred feet in thickness, is Permian of *some* kind. Then my argument will not be weakened, but considerably strengthened; for we have certainly nothing corresponding to such a series on this the

[1] Report of the Royal Commission on Coal, vol. i. pp. 136–8, vol. ii. p. 504; Physical Geology of Great Britain, 3rd ed. p. 302.

[2] Siluria, 5th ed. 1872, p. 335.

[3] Q.J.G.S. vol. xxv. p. 171.

[4] Q.J.G.S. vol. xxvii. p. 245.

East side of England. I need scarcely remind your readers that geologists, not omitting the Survey authorities, have long since abandoned the belief in the Permian age of Sedgwick and Murchison's "Lower Red Sandstone" of Yorkshire and Durham. "All along that range" (Nottingham to Tynemouth), says Prof. Ramsay, "the red rocks on which the (Magnesian) Limestone rests are now proved to be Carboniferous sandstones and shales. . . . . The *supposed* Rothliegende has indeed almost (? altogether) disappeared from the entire area."[1] The few feet of true dolomitic Magnesian Limestone at Skillaw Clough and a few other points in the West of England cannot for one moment be compared with the vastly thicker and more extensive deposits of Magnesian Limestone on the other side of the Pennine Chain. I must also beg to differ from Prof. Hull, when he refers to the Marl Slates of the North-east of England as a local and thin formation. We find Marl Slates accompanying the Magnesian Limestone through Notts and through Durham. I have lately recognized them in Yorkshire. In Notts they attain in places a thickness of over 100 feet, and under Lincolnshire of about 200.[2] They maintain throughout this wide area a remarkably characteristic facies. Thus Prof. Hull's objections to my argument for the pre-Permian age of the Pennine Chain—based on the dissimilarity of the Permian deposits on the two sides of that range—are singularly unfortunate.

This argument is not, however, as Prof. Hull seems to imagine, a crucial point in my hypothesis. Even if the Permian deposits of the West were closely allied to instead of being so very unlike those on the East of the Pennine Chain, this would not demonstrate the post-Permian age of that range. Similarity in texture, of fossils, and even of "set" or succession, between the rocks of a period in two adjacent areas, though no doubt indicating a general similarity in physical conditions and in sequence of events, would not suffice to prove original continuity of submergence between those areas. (Deposits now accumulating on the opposite sides of an island or peninsula or in two adjacent lakes may be undistinguishable, and their faunas may agree, and yet such areas are either wholly dissevered or only connected *in a roundabout way.*) All idea of direct continuity of submergence must even in that case fall to the ground when there is, as in the present instance, sufficient independent evidence of the existence of an intervening land barrier. E. Wilson.

BLOWING WELLS.

Sir,—A curious phenomenon has recently been brought under my notice observable at some of the wells in the uppermost part of the Bunter sandstone of this district. These wells "blow" through fissures in the sandstone, just above water-level. This is when barometric pressure is low, suction setting in as the mercury rises.

The most remarkable of these wells is one at Solberge near here. The blast at this well is conveyed above the ground by means of an

[1] Q.J.G.S. vol. xxvii. p. 245; Geol. Mag. 1872, Vol. IX. p. 339; The Yorkshire Coalfield, p. 482; Geol. Mag. 1866, p. 49; Q.J.G.S. vol. xxv. p. 291.

[2] Q.J.G.S. vol. xxxiv. p. 812.

iron tube inserted in the covers of the well and running up alongside of the pump. With an outward blast, this "buzzer," it is said, can be heard a mile off.

Mr. Fairley, the county analyst, pronounces the water "a hard water of good quality for drinking, but not for any purposes where softness is mainly due." On raising the covers of the well, the water is seen in a state of ebullition, which soon ceases.

The existence of a cavern in the strata has been suggested as the cause of the blowing wells in this district. The very considerable thickness of sandstone that probably intervenes between the bottom of the well, and the underlying Magnesian Limestone—the unlikelihood of any cavern existing in the sandstone itself—and the almost certain tendency the glacial sands would have to fall through any opening of the kind, causing a depression on the surface of the soil, of which there is no evidence, for the wells are situated on dome-shaped ridges of drift-covered sandstone, incline me to look for another reason for the phenomenon. I am more disposed to think that, taking into account the fissures in the sandstone, its origin may be traced to causes similar to those which produce explosions in coal-mines. These, I understand, generally take place at or about the time the barometer has reached its lowest point.

Mr. Hutton, of Solberge, takes much interest in the peculiar action on the part of his well, and registers the changes in velocity and temperature of the blast by means of the anemometer and thermometer. The barometrical observations, as already noticed, show that the direction of the current is dependent upon the weight of the atmosphere.

Mr. Fox-Strangways, F.G.S., tells me that he believes the great currents of air which issue from large caverns are more generally influenced by temperature than by barometrical changes, and that he has been struck with the enormous current of air which issues from the Mammoth Cave in Kentucky, but which is an incurrent during the night.

The existence of such wells, as are above described, is unknown to me elsewhere than in this neighbourhood.[1] Any information as to their occurrence in other parts of the country, might help to throw light upon a subject which is at present a puzzle to many in this district, and is, I cannot but think, well worthy of further investigation. There are borings or wells called "blow wells" on the Lincolnshire wolds, and on the coast of Essex, but I am unacquainted with their history.

A. G. Cameron,
H.M. Geol Survey.

Northallerton, *Dec.*, 1879.

[1] See Blowing Well near Preston described by J. Rofe, F.G.S., Geol. Mag. 1867, Vol. IV. p. 106.

Errata in Mr. W. Davies's paper, January, 1880.

Page 19, line 25 from top, for "rapprochait," read "rapproche."
" 25, " 13 from bottom, for "la," read "le."
" 26, " 23 from top, for "*Pelicanus*," read "*Pelecanus*," and in all subsequent instances to p. 27.

Erratum—January, 1880. In Mr. Kinahan's article, p. 29, line 23, for *Killarney* read *Killary*.

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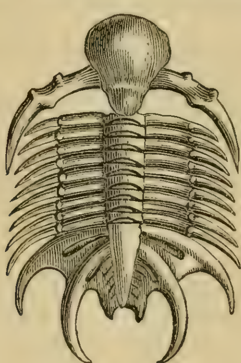
ORIGINAL ARTICLES.

I.—DESCRIPTION OF A NEW GENUS OF TRILOBITES, *ONYCOPYGE LIVERSIDGEI*, FROM THE SILURIAN OF NEW SOUTH WALES.

By HENRY WOODWARD, LL.D., F.R.S., F.G.S., of the British Museum.

A NEW and interesting species of Trilobite having lately been obtained by Professor A. Liversidge, F.C.S., F.G.S., of the University of Sydney, in the Silurian rocks of Bombala, New South Wales, and forwarded to my colleague, Mr. R. Etheridge, jun., F.G.S., with a series of other Palæozoic fossils, from Australia, it has been obligingly placed in my hands for description.

I was at first doubtful whether to treat this fossil as a new species of *Deiphon* or as a distinct genus, near to *Deiphon* and *Staurocephalus*; but on a further comparison of these forms with Professor Liversidge's specimen however, there appear to be such important points of difference in the body-segments and pygidium as to entitle it to be



Onycopyge Liversidgei, H. Woodw. (restored)[1] nat. size. Silurian, Bombala, New South Wales.

[1] The original specimen is preserved in a black and hard splintery limestone, and has been much broken, a part being seen in intaglio and a part in relievo. The position occupied by the hypostome in the fossil at the back of the glabella is indicated in the woodcut.

considered a distinct genus, having characters which, to some extent, approach both to *Deiphon* and *Staurocephalus.*

Onycopyge,[1] gen. nov.

Glabella broadly dilated in front, attenuated behind, the genal portion reduced to a stout recurved spine, bearing two or more short branch spines or tubercles; axis of body-segments narrow, arched; pleuræ straight, well-articulated, recurved at extremities; pygidium channelled, margin indented, armed on each side with long-recurved spines, extremity shortly bimucronate.

I have very great pleasure in dedicating this new Trilobite to its discoverer under the name of—

Onycopyge Liversidgei, sp. nov.

Animal $1\frac{1}{2}$ inch in length, by $1\frac{1}{4}$ inch wide; surface of test finely granulated; glabella spheroidal, broader than long, slightly compressed in front; eyes nearly concealed beneath the overhanging margin of the glabella; cervical lobe narrow; genal portion reduced to a long rounded strongly-recurved fixed spine, giving off two short, nearly vertical spines or branches (apparently directed forwards and upwards)[2] at a distance of one-fourth and half its length from the glabella; there is an indication of a third spine on each side directed backwards and inwards; (the facial suture cannot be accurately determined, but it no doubt ended on the exterior margin, as in *Deiphon Forbesii*, Barr.). Thorax broader than long (fourteen millimètres long, by twenty-eight mm. broad), consisting apparently of nine joints; axis narrow, convex; pleuræ united parallel, diverging at right angles from the axis; each pleura being articulated at its fulcral point, which is marked by a small rounded tubercle, and having its termination produced as a free recurved spine, the length of which increases from the first or anterior pleura to the ninth or last.

The pygidium has its axis extending to its posterior extremity (but the surface is broken away); the expanded border of the pygidium is somewhat deeply excavated into five rounded emarginations, principally formed by the two anterior coalesced segments of the pygidium, which, springing from the axis on either side, terminate in long and strongly-recurved marginal spines; they are separated from each other by deep intersecting furrows; behind these we detect indications of five coalesced somites; the pygidium terminates posteriorly in two short cusps separated by a rounded central emargination.

The head in *Onycopyge* agrees most nearly with that of *Deiphon*, the cheeks being reduced in both to long recurved rounded spines; but the glabella is less globular, and the eyes less prominent in the former than in *Deiphon.* The hypostome in *Onycopyge*, although only imperfectly preserved, agrees more nearly with *Deiphon* than it does with *Staurocephalus.* It is exposed by the abrasion of the postero-dorsal surface of the glabella (see Woodcut).

[1] ὄνυξ, *ονυχος*, a claw; and πυγή, tail.

[2] The extremities of these branches or spines are broken off, so that their length is not known.

The most important points of difference between *Onycopyge* and *Deiphon* are observable in the thorax or middle-body, the pleura in the former genus being firmly articulated to one another at the fulcral points, whereas in the latter they are ungrooved and free. The pygidium in *Deiphon* is short, with a minute axis of four joints, and is quite truncated below; the pygidium in *Onycopyge* is well developed, and has indications of seven coalesced somites. *Onycopyge* apparently possessed nine free thoracic somites; *Deiphon* has ten somites.

With *Staurocephalus* it agrees in the more compact and firmly articulated character of the thoracic somites; in *Onycopyge*, however, the extremities of the somites lengthen perceptibly from the head to the pygidium; whereas in *Staurocephalus* the anterior pleuræ are the longest.

In *Staurocephalus* the genal portion of the head is not reduced to a mere spine (as is the case in *Deiphon* and *Onycopyge*), but has well-developed fixed cheeks. The pygidium in *Staurocephalus* is composed of four minute coalesced somites; and when provided with prominent spines it has, like the genus *Deiphon*, one spine only on each side.

It is to be hoped that this interesting Trilobite is only the precursor to many others which Professor Liversidge may have the good fortune to obtain, and I may have the pleasure to describe, from the Australian Continent.

II.—Note Upon the Cooling of the Earth.

By Prof. J. Milne, F.G.S.,
Imperial College of Engineering, Tokei, Yedo.

NEARLY every text-book on geology speaks of the heat which has been lost by the earth, and the consequent contractions which have taken place upon its surface. The way in which all this has come about, however, is either not explained at all or else very imperfectly, and the difficulty experienced by any one endeavouring to find out what the conditions have been will be fully recognized by reference to the lengthy correspondence which was carried on in the columns of *Nature* (December, 1878, and January, 1879) between Mr. A. R. Wallace, Mr. O. Fisher, and others, upon this subject. A fair idea of the succession of conditions which occur in a cooling sphere like our earth may be obtained by combining together the results given by Sir William Thomson in his writings on the secular cooling of the earth (see Thomson and Tait's Natural Philosophy, vol. i. pp. 711–727), with the results given by Professors Perry and Ayrton in a paper entitled, "Experiments on the Heat Conductivity of Stone" (Phil. Mag. April, 1878). In this latter paper we have given, and I believe for the first time, a series of curves which show the rate of cooling of a ball at its various parts. Two of these curves are reproduced in the accompanying figure, Fig. 1. *PA* represents the cooling at the centre, and *PF* the cooling at the circumference, the direction *OP* measuring temperature, and the direction *OX* measuring time. Curves for intermediate points between the centre and the circumference may be seen in fig. 6 of the paper from which these two have been reduced.

From this we see that when a ball is made hot, and we may imagine this ball to be the earth, when it cools it does so at very different rates in its different parts.

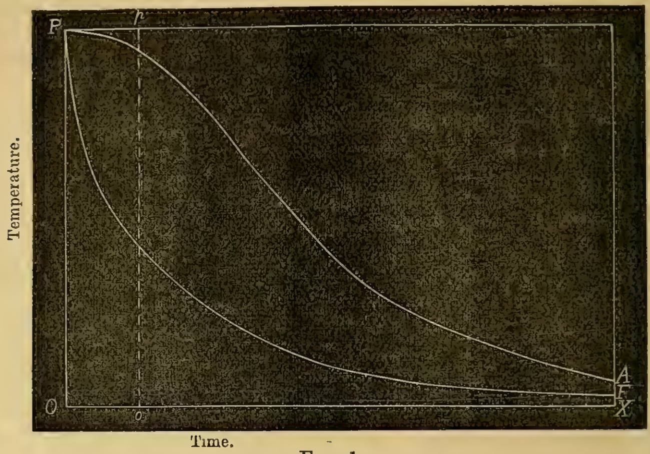


Fig. 1.

Thus the external part, if the ball is at a high temperature, will cool exceedingly rapidly at first, and this rapidity will grow less and less. The cooling of the centre, however, will be different. For some period it will cool slowly, after which it will cool with a rapidity which continually approaches the rate at which the circumference cools, until eventually it cools even faster than the circumference. Intermediate places at the beginning cool more slowly, as they are nearer the centre. For each of these, however, there is a certain interval, after which they cool faster than places in the circumference. From what we know of the earth, its interior is probably yet very much hotter than points near the surface; points near the surface are therefore probably still cooling at a rate much quicker than points near the centre, and the cooling which has so far taken place in the earth may be represented by the parts of these two curves, which are included between *OP* and some line like *op*.

Messrs. Perry and Ayrton, in this series of curves, have given the true conditions for a cooling globe, whose surface had a given emissivity; but Sir William Thomson, whose calculations satisfy very well the known conditions of the earth, used a much greater emissivity.

In fact, Sir William Thomson assumed so great an emissivity for the surface of the earth, that after 10,000 years from the commencement of superficial solidification of the earth there was no farther change of temperature at the surface, and this is practically equivalent to an instantaneous cooling of the earth's surface to its present temperature, and maintaining that temperature constant. This assumption is supported by the well-known instance of the rapid cooling of a mass of lava, and by the fact that the result obtained satisfies observations of the present temperature of the earth.

Assuming, then, that Sir William Thomson's result is correct, it would seem that we should be hardly justified in employing his result for very great depths in the earth, because in his calculations he did not consider the cooling of a globular mass, but of an infinite mass of rock with a plane surface. In Fig. 2, the curve OM is

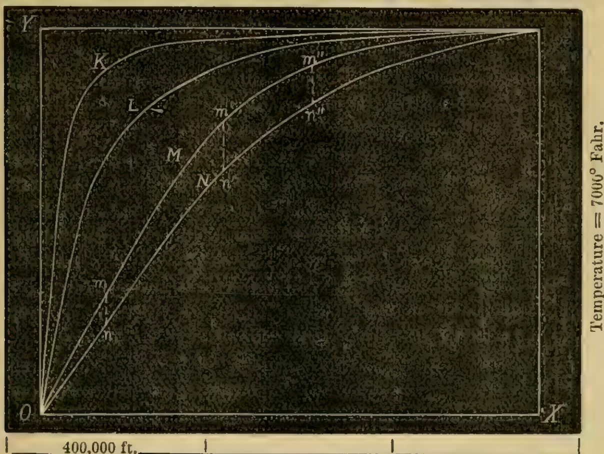


Fig. 2.

reduced from Thomson and Tait's Natural Philosophy, vol. i. p. 719. It represents the distribution of temperature in the earth one hundred million years after the commencement of cooling, the initial temperature being 7000° Fahr., and it also, so far as we know, represents the distribution of temperature in the earth as determined by experiment. The direction OY measures temperature, and the direction OX distance, from the surface at O towards the centre at X. The curves OK and OL are sketched to show approximately what the distribution of temperature was previous to this period, and the curve ON to show what it will be subsequently, say for example 10,000 years hence.

Up to a depth of about 100,000 feet, according to Thomson, or according to the curve he has given approximately to a depth of nearly 80 miles, the temperature increases directly with the depth (1° F. for 51 feet descent). After, say 10,000 years, the temperature will, according to the curve ON, increase directly with the depth for a depth greater than 80 miles.

MN represents the loss of temperature in 10,000 years at a depth of 100,000 feet, $m'\,n'$ at 400,000 feet, $m''\,n''$ at 600,000 feet, etc. By comparing together the losses of heat which have occurred at different points, it will be seen that there will be a spherical belt where the loss during any given period is greatest and this is travelling towards the centre.

At the present time, up to a depth of about 200,000 feet, we see that the loss of temperature is nearly proportional to the depth. At the commencement the temperature was supposed to be that of melted rock, or as an extreme limit about 7000° Fahr. In a short period the surface solidified; in fact, points near the surface obtained very quickly a temperature nearly the same as it is at present. Parts near the centre, however, hardly cooled at all, and even now the temperature at the centre is probably the same as it was one hundred million years ago.

From all this it would appear, as is pointed out by Sir William Thomson, that because in early times the increase in temperature as you descended into the earth was more rapid than it is at present, all changes due to plutonic action must have been more active in early times than they are now.

Also we see that it is very probable that the main features of the earth's surface, like the continents and ocean-basins, are of great antiquity, having in fact been formed at or about the time of first consolidation.

Heat received from the sun.—From experiments with the Pyrheliometer it has been calculated that every year the earth receives from the sun a quantity of heat sufficient to melt a layer of ice covering the whole surface of the globe 100 feet in thickness. This is equivalent to 92 feet of water raised 79° C. or 72·7 feet raised from 0° to 100° C. (Tyndall, in his "Heat a Mode of Motion," gives this as 66 miles.)

Heat lost by the earth.—The heat which is lost per year by the earth may be determined from the present gradient, which is about 1° for 50 feet of descent, and the conductivity of rock, which we will assume as being ·0059. If we calculate this, we shall find that it is sufficient to raise a layer of water covering the whole surface of the earth ·677 centimeters in thickness from 0° to 100° C.[1]

This is the absolute loss. The energy received from the sun is partly spent in the growth of trees, the elevation of water, etc., and part is radiated off into space as soon as it is received, but whatever becomes of it, we can definitively say that the above quantity of heat is being actually lost by the earth.

[1] Let the heat gradient of the earth be 1° F. for 50 feet of descent, or in Centigrade scale and centimeters $\frac{5}{9}$° C. for 50 × 30·5 centimeters in descent. Let the area of the earth in square centimeters = S. Let the conductivity of the rocks = K = ·0059. Then the amount of heat lost by the earth per year

$$= S \times \cdot0059 \times (\tfrac{5}{9} \div 50 \times 30\cdot5) \times 365 \times 24 \times 60 \times 60.$$

An ocean over the earth d centimeters deep would be heated from 0° C. to 100° C. if

$$S \times d \times 100 = S \times \cdot0059 \times (\tfrac{5}{9} \div 50 \times 30\cdot5) \times 365 \times 24 \times 60 \times 60.$$

Whence d = ·677.

That is to say, an ocean covering the whole surface of the earth ·677 centimeters deep, might be raised from 0° to 100° C. by the heat which flows from the earth every year. This heat is heat of a low temperature.

III.—On the Pre-Cambrian Rocks of West and Central Ross-shire.

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

With Petrological Notes.

By T. Davies, F.G.S., of the British Museum.

(PLATE IV.)

A PORTION of the district referred to in this paper was described by me in a communication to the Geological Society, on May 22nd, 1878, and this was afterwards published in the Quart. Journ. Geol. Soc. vol. xxxiv. In that paper, however, many of the facts which had led me to the conclusions stated therein had to be omitted, and the important evidence derived from the microscopical examination of the rocks was hardly touched upon. It was then intended that this evidence should be given in an appendix to the paper, but, unfortunately, circumstances at the time prevented it.

As, since then, doubts have been expressed as to some of the interpretations given, it is not altogether, perhaps, to be regretted that this delay has occurred; especially as it has enabled a larger series of petrological observations and comparisons to be made.

In entering at first upon this inquiry, my main object was to endeavour to realize, by geological and petrological observations, the relationship to be made out between the gneiss rocks of the North Western Highlands, and the Pre-Cambrian rocks of Wales, upon which I have been working for so many years. Other questions, however, arose in the course of the inquiry, and some conclusions were arrived at, which have necessitated a more detailed arrangement.

In the petrological descriptions (as on many previous occasions) I am greatly indebted to the experienced aid so readily given by Mr. T. Davies, F.G.S., of the British Museum. His long acquaintance with the minerals and microscopical characters of the older or Pre-Cambrian rocks, from various countries, and well-known labours in petrology generally, render his notes specially valuable in this inquiry.

Gaerloch, Poolewe, and Loch Torridon.

In the area to be described (see map) the most westerly exposures of the Pre-Cambrian rocks are to be found at and about Gaerloch. To the N. and E. of this place, over a considerable district, they are uncovered by newer formations, but westward along both sides of the loch, Cambrian sandstones and conglomerates lie at low angles on the up-turned edges of these older rocks. In so extensive an area, as would naturally be expected, considerable differences occur in the composition of the rocks at various points, and those varieties which appear most characteristic of the group in one place, may be entirely absent at another. Hitherto no detailed observations seem to have been made on these rocks in this area, but a few special varieties have been noted by Macculloch, Nicol, and Murchison in their papers. They have been generally designated "fundamental gneiss," and associated with the western gneiss of Sutherland, and of the Hebrides. In a general way this may be correct; but as it is now granted by many that these rocks are metamorphosed sediments, a detailed description of all the varieties noted in each separate area seems to be the only true method by which a correlation can be attempted. Evidence of age also in proportion to their crystalline condition, and the mineral change which has taken place, is frequently a still better guide to correlation, and should be carefully noted in all cases.

The physical evidence of having been subjected to contemporaneous movements, as indicated by a prevailing strike in the beds, as insisted upon by Murchison, is undoubtedly also of immense importance, and should never be lost sight of in these inquiries.

In the paper already referred to I mentioned that some of the so-called eastern gneiss rocks of Central Ross-shire about Ben Fyn, etc., were almost identical in character with some of the western gneiss which I had examined about Gaerloch. It is well known that Murchison, Geikie, and others maintained that there is a great dissimilarity between the two groups everywhere. Physically and mineralogically they are utterly unlike according to these authors. Nicol, and before him, Cunningham and Macculloch, considered them on the whole to be more or less identical, or at least sufficiently so to be associated together in one great group. Though differing from the last-named authors on some points which will be specially referred to again, I yet agree with them that the eastern and western series (excluding some beds which I consider to belong to the unaltered Cambrian and Silurian sediments) are sufficiently identical in their mineral characters, in their crystalline conditions, and in their physical aspect generally, to belong to the same great group of metamorphosed sediments of Pre-Cambrian age; necessarily unlike in some respects, at various horizons, but showing everywhere characters special enough to prove that they have been equally subjected to the same influences throughout, whether chemical or physical.

To prove this it will be necessary to examine carefully into the completeness or otherwise of the changes which have taken place in all the types of rocks found in each area, and whether there has been throughout an equal *change of constitution* in those which appear to be sufficiently identical for this comparison to be made. If we find that these rocks are equally metamorphosed, and that there is an equal amount of various crystalline minerals disseminated throughout which could not have been present, in that state, in the original sediments, then we may fairly claim that the rocks have undergone an equal change of constitution: and therefore that they must have been subjected to the same long-continued influences, and are geologically speaking of the same age.

The strongest advocates of the views held by Murchison, that the eastern types of gneisses, hornblende rocks, mica schists with garnets, etc. (true crystalline schists found in many parts of Central Sutherland and Ross and other parts of the Highlands), are younger than the Cambrian, and of some of the Silurian rocks, have in no case, as

Diagrammatic Section across Ross Shire.
a. Pre-Cambrian. b. Cambrian. c. Silurian. +. Intrusive rocks f. Faults.

far as I can make out from their published statements, been able to show conclusively any continuous sections in which these are actually seen to repose conformably on the Cambrian rocks, or on the sandstones, limestones, and micaceous flagstones and slates of Silurian age. These last, when altered, are partially so only, from actual contact with some intrusive rock. Moreover, these Silurian beds lie almost invariably at very low angles, usually with a dip from 10° to 30°, and sometimes they may be said to be horizontal.

The crystalline schists, on the other hand, which are supposed to lie conformably on these unaltered flags and slates, everywhere in the eastern, like those in the western areas, lie at high angles, the dip being seldom under 50° and usually from 70° to 80°. There is generally also a complete discordancy in the strike, when it can be traced for any considerable distance.

The nearer we approach to the earliest history of the globe, the more likely are we to meet with similarity of composition in the majority of the rocks, and hence it is that though we speak of many varieties, yet it will be seen that the minerals which enter into their composition are comparatively few, the differences being chiefly in the preponderance or otherwise of any of these

Quartz, felspar, mica, and hornblende are the minerals which characterize the majority of the rocks in this area; but chlorite and other minerals are also frequently present. Limestone bands also occur interstratified with the gneisses at two or three horizons. As accessory minerals, garnet, epidote, and sphene are common. Some of the rocks consist almost entirely of quartz, others of felspar, or mica, or hornblende; but the majority of a varying admixture of these minerals.

On the shore between the Strath Hotel and Gaerloch Kirk a considerable thickness of very pure mica schists (or slates), with a silvery lustre, and containing garnets, occur. They dip at a high angle, with a general N.W. strike, and upon their upturned edges the Cambrian conglomerates, made up largely of masses derived from these and other underlying rocks, lie almost horizontally. In ascending the hill to the N., a variable series of schists and gneiss rocks are seen, dipping regularly upon one another at high angles, usually in thin beds, easily separable also into thin laminæ along the line of bedding, and but very slightly contorted. Many are of a dull and some of a light green colour, but the majority are red or grey, or consist of thin alternating laminæ of these several colours. There are very few beds here of the strong gneisses usually found in and supposed to be so characteristic of the western groups; the majority here may be associated more correctly with the chloritic and micaceous schistose rocks. Another variety found is a gneiss of a bright red colour, due almost entirely to the abundance of minutely crystalline garnets present.

Collectively the schists found in this and the adjoining mountains, on the same line of strike, do not remind one of the usual descriptions which have been given of the western Pre-Cambrian rocks; but rather of some of those more frequently referred to by authors as characteristic of the so-called newer or eastern metamorphic groups. Their thickness here is very considerable, and they doubtless therefore are to be found in other western areas. That they belong to the Pre-Cambrian rocks there can be no doubt whatever, as evidenced by the vertical position of the beds, their strike, and intimate association generally with the typical gneisses of the district.

Moreover, the Cambrian rocks rest horizontally upon their upturned edges, and may be seen in this position not only along the shore, but high up in the mountains. That they were also in their present altered position before the Cambrian rocks were deposited upon them is clear from the abundance of fragments found in the conglomerates at the base of those rocks.

A more quartzose variety found in association with these dark schists is described in the subjoined Note 1 by Mr. Davies; and a light red highly felspathic compact gneiss found interstratifying the same schists rather high up on the same face of the mountain looking over Gaerloch, and very conspicuous amongst the darker schists by its colour, is described in Note 2.

Hornblende is usually absent in the quartzose gneisses here, as well indeed as in the majority of those to the north and south of this immediate area. Its place seems to be taken up almost entirely by black mica, and in this these gneisses differ markedly from those usually described as characteristic of other western areas and of the Hebrides.

This is the more remarkable also, as it will be seen that hornblende rocks and schists are plentiful in many parts of the district to the North and South. The felspar is also of a lighter colour on the whole, than in the Lewisian gneisses, being usually white or pale pink.

[Note 1.—A very micaceous schistose rock, resembling a fine-grained mica quartzite, or a mica-schist. A microscopic section shows quartz in small grains, crystalline, but not intimately so, the grains being usually isolated. Nests of quartz are not infrequent, around which the mica curves. The orthoclase felspar being much altered and principally filling the spaces between the quartz grains is not easily recognizable; but the plagioclase is in a fresher condition. Occasionally large crystals of orthoclase occur, in which are inclosed numerous quartz grains. The predominant mica is biotite, though a monochromatic mica is frequent, both of which, besides their general parallel directions, are frequently developed at all angles to the plane of foliation. Small garnets and exceedingly minute sphene are frequently to be observed.—T.D.]

[Note 2.—Macroscopically this is a pale pinkish red gneissic rock, apparently consisting of felspar and quartz only, and is very fine-grained. Microscopically it is found to be made up of an intimately crystalline mass of felspar and quartz in fine grains. The quartz appears also as individual grains inclosed in the felspar crystals. But this constituent here takes the position of the mica in the preceding rock. To its development into more or less continuous wavy bands, bulging out here and there by the growth of a larger quartz crystal, the whole of the gneiss-like aspect of this rock is due. The felspar is principally orthoclase, much altered, and with a little plagioclase is occasionally developed into larger crystals. Mica is very sparse, scattered irregularly through the mass, though a very few attenuated waves of folia are present, consisting principally of muscovite. Limonite as pseudomorphs after minute cubic crystals of iron pyrites is frequent throughout.—T.D.]

I was unable to examine the district further north towards Poolewe, but Prof. Seeley, who had gone over this ground some time previously, has kindly allowed me to examine a collection made by him in that direction. In speaking of the rocks generally, he says that he found a great variability amongst them. This agrees with what I noticed also in travelling further east on a parallel line, and probably across the same beds. Amongst Prof. Seeley's specimens may be mentioned chiefly some highly quartzose gneisses, an *augen-gneiss*, a large-grained very dense hornblende rock, and a hornblende gneiss, all as nearly as possible identical with specimens I collected in 1878 at Ben Fyn (in the so-called eastern gneiss). Other rocks which may be considered perhaps by some more typical even than these of the western gneiss occur here also, such as a reddish felspathic rock with strings of epidote permeating it, and a large-grained granitoid gneiss, Note No. 3. A band of limestone also has been mentioned by Murchison running parallel to the gneisses to the S.E. of Poolewe.

[Note 3.—A medium-grained crystalline rock consisting of quartz, orthoclase, and some plagioclase with mica. The latter constituent, in addition to its irregular distribution throughout the rock, forms also thin bands which are more or less parallel, and to which its gneissic aspect appears to be entirely due. Seen in thin section the intimate crystalline structure of the constituents greatly resembles that of a typical granite, where the minerals are developed without any tendency to parallelism; the evidences of a foliation here being entirely absent except in the wavy bands of mica. The quartz which constitutes the larger part appears to be remarkably free from fluid inclusions, though traversed by numerous bands of exceedingly minute grains, which under a $\frac{1}{4}$-inch objective are resolved into minute spherical and oval cavities which appear to be empty, as I failed to recognize in any of them the usual indications of fluid contents. Orthoclase is the predominant felspar, and as well as being in a partly altered condition, is more or less obscure, owing to the presence of abundance of similar minute empty cavities as occur in the quartz. Similar inclusions, though mostly containing fluid, were recognized by Zirkel[1] in the orthoclase of the gneisses of the Clover Cañon, Humboldt Mountains, Nevada. Both the felspars frequently inclose individual crystalline grains of quartz, which from their rounded contours recall to mind the quartz of many quartz-felsites. Plagioclase is much less frequent, is in fresher condition and nearly free from inclusions. Mica is dark greenish-brown, strongly dichroic, and is probably biotite. Sphene with a little

[1] Microscopical Petrography, by Ferdinand Zirkel, Washington, 1876, p. 17.

magnetite and a few minute garnets are scattered through the rock, the sphene being more frequent in the mica bands.—T.D.]

In the district to the S.E., and along the road extending from Slattadale, on the shore of Loch Maree, to Lake Padnascally, nearly all the varieties of the gneiss and schistose rocks already mentioned are met with. The abundance, however, of black mica found in some of the beds along this line is remarkable. In some places it forms a dense black rock, containing occasional nests of felspar and very thin lines of quartz, but otherwise consisting almost entirely of this mineral. These rocks and the gneisses described in Notes 4 and 5 occur about Slattadale and along the south-west shore of Loch Maree.

[Note 4.—This rock presents the aspect of a fairly typical gneiss. It is composed of a mixture of two felspars with quartz, and numerous alternating bands of black mica containing much sphene in pale yellow grains and crystals. In thin section it much resembles the rock No. 3, the intimate intergrowth of the quartz with the felspar being strikingly similar, the main differences consisting in the more numerous and often closely-packed mica bands and the greater abundance of the felspars. The quartz here is sometimes developed in continuous bands, which resemble lengthened-out crystals, and it is only by the use of polarized light that these are shown to consist of numerous closely-developed crystals. They lie more or less parallel with those of the micas. The individual rounded crystals inclosed in the felspars are not so frequent here. The minute empty cavities are also abundant, while small plates of mica are frequently also included. Orthoclase is in crystalline masses, somewhat altered, with a little plagioclase. They are intimately crystalline with each other and with the quartz, this latter constituent is in about equal proportion to that of the felspars combined. The mica is of the same species as in the preceding rock. Sphene is abundant, and more so in the biotite bands.—T. D.]

[Note 5.—This rock both macroscopically and microscopically strikingly resembles the last described. The quartz and the felspars bear the same crystalline relation to each other, and the latter constituent is in much the same degree of alteration. The main difference consists in the abundance of the mica (which is also characterized by a greater opacity and stronger dichroism), and the sphene crystals, which are so thickly aggregated in some places as to crowd out the ordinary constituents. Garnet is also present, but is not frequent. Here and there is a little green hornblende.—T. D.]

Between Lake Padnascally and Gaerloch, along the line of the Kerrie River, hornblende rocks prevail, usually as hornblende slates and schists. At and about the falls of Kerrie these slates dip so evenly and regularly that at a distance one can hardly realize that they are not ordinary Silurian slates. They are, however, on closer examination found to be highly crystalline rocks, the whole surface being covered with fine needle-like crystals of hornblende. Some are more coarsely crystalline, but the majority here are fine-grained. The beds dip at a high angle, to the N.E., and usually are not at all contorted. The specimen described, Note 6, is from near this spot.

[NOTE 6.—A close fine-grained slate, which is seen with a pocket lens to consist of exceedingly small acicular crystals of hornblende, constituting a hornblende slate or what has been designated a schistose amphibolite. Examined in thin section the yellowish-green thin hornblende needles are seen to form the mass of the rock; they lie in closely aggregated parallel position with a small amount of interstitial quartz, which occasionally breaks into a crystalline nest. —T.D.]

In a direction south from this place a narrow strip only of the Pre-Cambrian rocks is found uncovered, extending chiefly along the lines of valleys. On the sides of which mountains of Cambrian conglomerates and sandstones rise up, in some cases, as at Ben Alligin, to heights of over 3,000 feet. On the shores of Loch Torridon a very small area again remains uncovered. Where exposed, the rocks are of the types of the gneisses and schists already described. Many of them highly quartzose, but the felspar is more frequently here of a reddish colour than in those described about Gaerloch and Poolewe. The Cambrian sandstones [not generally here containing such large masses of rocks as at Gaerloch] rest as nearly as possible in a horizontal position on the edges of the older rocks, and this horizontality of the beds continuing from mountain to mountain with highly precipitous cliffs is a marked feature as they stretch along the shores. No more remarkable geological scenery is scarcely to be found than is exhibited in the successive mountains of Torridon sandstone traced along the shores, and along the valleys leading to this Loch. The enormous destruction of the older rocks that must have taken place ere these mountains could have been built up, and the equally enormous denudation that must have subsequently taken place to have completely uncovered these older rocks again in so many areas and valleys, cannot fail to arouse some feelings of astonishment even in the geological mind.

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

IV.—A CONTRIBUTION TO THE STUDY OF THE BRITISH CARBONIFEROUS TUBICOLAR ANNELIDA.[1]

By R. ETHERIDGE, jun., F.G.S., F.R.P.S.Edin.

THE study of the Palæozoic Tubicolar Annelides has not received that amount of attention which the importance of the Order, either from a geological or zoological point of view, appears to demand. True it is that many interesting and instructive papers and memoirs have from time to time appeared, containing descriptions of species, and occasionally of genera; but, so far as I know, at any rate in this country, no connected account of either Silurian, Devonian, or Carboniferous Tubicolar Annelida has appeared.

The present paper is an attempt to remedy this to a certain extent, in so far as our Carboniferous forms are concerned, although it in no way pretends to be either an exhaustive or satisfactory account, but merely a contribution towards that end.

[1] The Plate illustrating this paper will appear with a *later part*.—EDIT. G. M.

The material upon which the following remarks are based comprises a collection from the Carboniferous rocks of Scotland, for the loan of which I am indebted to the kindness of Prof. A. Geikie, LL.D., F.R.S., the specimens contained in the Museum of Practical Geology, those of the British Museum, and a few kindly contributed by various collectors. The specimens in the Survey Cabinets, both of Edinburgh and London, are the result of collections made by Messrs. J. Bennie, A. Macconochie, and the late Mr. R. Gibbs.

I am particularly indebted to my friend Mr. Bennie, who has done his utmost in every way to gather facts and specimens from all quarters, and has aided me with many valuable suggestions. I have also to thank Mr. E. W. Binney, F.R.S., who some years ago permitted me to examine his collection of *Spirorbis.*

The result of numerous observations in the field has shown that our Carboniferous Annelides, so far as habit is concerned, place themselves under three headings or conditions, viz.:

a. Those leading a solitary life attached to Mollusca, Corals, Polyzoa, and other submarine objects—types *Spirorbis caperatus,* M'Coy; *Ortonia carbonaria,* Young.

b. Those occurring in small clusters of individuals, too many in contiguity with one another to be termed solitary, but not in sufficient quantity to constitute a rock-mass—types *Serpulites carbonarius,* M'Coy; and frequently *Spirorbis pusillus,* Martin.

c. Those forming rock-masses, *i.e.* occurring in such quantity that their shells or tubes after fossilization give rise to the formation of bands of limestone and other rock, often many feet in thickness—type *Spirorbis helicteres,* Salter.

The following table shows the distribution of the British Carboniferous species according to the above results:—

a. Solitary species.

Spirorbis ambiguus, Flem.	*Spirorbis pusillus,* Martin.
,, *Archimedis,* de Kon.	,, *spinosa,* de Kon.
,, *Armstrongi,* Eth. jun.	*Serpula indistincta,* Flem.
,, *caperatus,* M'Coy.	*Ortonia carbonaria,* Young.
,, *Dawsoni,* Eth. jun.	*Ditrupa Ryckholti,* Eth. jun.
,, *Eichwaldi,* ,,	*Vermilia,* sp.
(,, *globosus,* M'Coy.)	,, *minuta,* Bronn.
,, *intermedius,* M'Coy.	

b. Gregarious, or in clusters.

Spirorbis pusillus, Martin (in part).	*Serpulites membranaceus,* M'Coy.
Serpula Torbanensis, Eth. jun.	*Sabella antiqua,* M'Coy.
Serpulites carbonarius, M'Coy.	

c. Forming rock-masses.

Spirorbis helicteres, Salter.	*Spirorbis pusillus,* Martin (in part).

Genus I.—*Spirorbis,* Lamarck, 1818.

(Hist. des Anim. sans Vertèbres, vol. v. p. 358.)

Section *Microconchus,* Murchison, 1839.

(Compare *Spiroglyphus,* Daudin, 1800.)

Microconchus, Murch., Sil. System, 1839, p. 84.
Nautilus, Hibbert, Trans. R. Soc. Edin. 1836, xiii. p. 151.
Spirorbis, Binney, Mem. Manchester Lit. and Phil. Soc. 1852, x. p. 196.

Gyromices, Göppert, in Germar's Verstein. Steinkohlen. Wettin u. Löbejün. 1853, heft 8, p. 29 (III.).
,, Geinitz, Verstein. Steinkohlenform. in Sachsen, 1855, p. 3.
Microconchus, Pictet, Traité de Paléontol. 1857, iv. app. p. 710.
Gyromices, Geinitz, Dyas, 1862, heft 2, p. 133.
Palæorbis, Van Beneden et Coemans, Bull. l'Acad. R. Bruxelles, 1867, 2me Ser. xxiii. p. 390.
,, Goldenberg, Fauna Saræpontana Foss. 1877, heft 2, p. 4.

Chars.—Tube dextral, or sinistral, attached by one side; simply spirally coiled, or the last volution extended into a free tortuous tube of greater or less length, but usually short; chambered or quite non-septate. Section circular, or elliptical; margin of the aperture or mouth of the tube round or a little sigmoidal; attached side flattened or irregular, attachment taking place by the whole, or only a part of the surface; sometimes forms for itself a depression in the substance of the body to which it is fixed. Surface plain, or ornamented with microscopic concentric striæ, or coarse annulations; sometimes produced into spines along the periphery of the tube, or each annulation forms a projecting lamella, or the surface may be generally spinous, whilst occasionally fine spiral striæ are present. Habit solitary, or found in large numbers together.

Obs.—The foregoing diagnosis is drawn up to include the small tubicolar Annelides of our Carboniferous rocks (and it may be said Palæozoic rocks generally), usually referred to *Spirorbis*, and in some instances to *Serpula*. With the view of expressing their separation and probable distinctness from the living *Spirorbis*, and those found in much younger rocks, I have employed the name introduced by Murchison as a sectional term under *Spirorbis*. This will, in a measure, tend to mark and retain as a separate group a very interesting series of forms, differing in some minor particulars from the recent *Spirorbis*, but still clearly allied to them.

The history of *Microconchus* will be found under that of the type species, *M. pusillus*, and it will only be necessary to notice now one or two points of general interest. In the first place, at least two species form for themselves depressions or hollows, corresponding to their outline, on the surface of those substances to which they are attached, whether animal or vegetable. With regard to the latter it might be contended that these hollows were caused by the pressure of the hard tube on the softer vegetable substance during entombment, and subsequent fossilization. In many cases, however, it can be unmistakably shown that the *Microconchus* has become inclosed within the substance of the plant, and in the case of shells, on which certain species occur plentifully, it appears to pass under the epidermis or outermost shell-layer. So marked is this, in the case of a species occurring in the uppermost Silurian beds at Lesmahagow, that specimens of *Modiolopsis*, one of the characteristic fossils of the beds in question, and preserved as internal casts, are perfectly riddled with these little parasites, which have left their impressions deep in what would have been the shell-substance. Similar facts can be studied in connexion with the *Anthracomyæ* and other bivalves of the Wardie Shales, where *Microconchus* occurs in thousands, and under the same conditions, except that the shells in this case are not preserved as casts.

This power of burying itself in the substance of other bodies, although possessed by a species, does not appear to be always taken advantage of, for examples of *M. pusillus* are as common at certain localities, simply adhering to the surface of other organisms, as they are elsewhere when forming a depression in the substance of the body to which they may have attached themselves.

In connexion with this habit of forming a depression in other bodies, we must refer to the genus *Spiroglyphus*, a name applied by M'Coy in 1844 to a Carboniferous worm possessing this peculiarity. M'Coy gives the genus as by Lamarck, but without any reference. So far as I have been able to ascertain at present, Lamarck never described such a genus; but there was one so named by Daudin as early as 1800, although it appears to be very little known or quoted. Both Bronn[1] and Pictet[2] ascribe *Spiroglyphus* to M'Coy, and were evidently unacquainted with Daudin's description, whilst Morris[3] follows much in the same track. The late Dr. S. P. Woodward[4] placed *Spiroglyphus* provisionally as a subgenus of *Vermetus*, but he cautiously remarks, "Perhaps an Annelide?" Lastly, Dr. Chenu assigns the genus to Gray! and, like Woodward, regarded it as a subgenus, but of *Siphonium*.

On turning to Daudin's little work,[5] we find *Spiroglyphus* regularly defined as a "Tubular shell, in an irregular spiral, and forming for itself a bed, or groove, on the surface of other marine shells," and placed near *Serpula* and *Spirorbis*, with which Daudin considered it to be allied. He further describes two species from the Indian Ocean, *S. politus* and *S. annulatus*.[6]

Now, if any deviation from the name *Spirorbis* is to be adopted for these Carboniferous worm-tubes, we have before us the choice of *Microconchus*, Murchison, a name under which they are frequently known; or *Spiroglyphus*, Daudin. Notwithstanding the great gap existing between an Annelide of the Carboniferous and one now living, I fail to see clearly how they can be separated. If future researches should show connecting links throughout the other formations, *Spiroglyphus* will have to be adopted. It has priority in date, and the double advantage of having been described in detail by its author. In subsequent pages I shall use the following subdivision of *Spirorbis*, thus:—

(*a*). *Spirorbis* proper. Worm-tubes possessing the generic characters, and simply seated on and adhering to the surface of foreign bodies.

(*b*). *Microconchus*, Murchison (= *Spiroglyphus*, Daudin ?), possessing the previous characters, but with the habit of, at times, making a depression or groove in the surface of the sustaining body.

Another point of much interest in connexion with these Annelid remains is the camerated, or septated character, of the tube in some species. This feature was many years ago pointed out by

[1] Index Pal. p. 1184.

[2] Traité de Pal. ii. p. 590.

[3] Cat. Brit. Foss. 2nd ed. 1854, p. 94.

[4] Man. Mollusca, p. 133.

[5] Receuil de Mémoires et de Notes sur les Espèces inédites ou peu connues de Mollusques, de Vers, et de Zoophytes, 12mo. Paris, 1800 (p. 39).

[6] pp. 49 and 50.

Dr. Eichwald as occurring in a species which he described under the name of *Spirorbis Siluricus*,[1] in which incomplete septa are said to separate the tube into chambers. Before this, however, Daudin wrote as follows regarding *Serpula Melitensis*: "The fossil *Serpula* of Malta (*S. Melitensis*) also appears to depart from the type of the genus, as it is chambered within; it is of importance to ascertain if its septa are entire as in *Tubipora*, or perforated as in *Orthoceras*."[2] More recently, Mr. J. Young, F.G.S.,[3] has described a similar segmentation in a British Carboniferous form, *M.* (*Serpula*?) *helicteres*, Salter, and in two recent species of *Serpula*. The diaphragms in Salter's species are said to be complete, and placed at irregular distances.

1. Sp. (*Microconchus*) *pusillus*, Martin, sp.

Conch. (*Helicites*) *pusillus*, Martin, Pet. Derb. 1809, t. 52, f. 2 and 3.
Microconchus carbonarius, Murchison, Sil. Syst. 1839, p. 84, f. D1-D10, p. 88.
„ „ Phillips, Brit. Assoc. Rept. for 1836, pt. 2, p. 87.
Nautilus, sp., Hibbert, Trans. R. Soc. Edinb. 1836, xiii. p. 151.
„ sp., Rhind, Excursions around Edin. 1836, p. 35.
Spirorbis omphalodes, Portlock, Geol. Rept. Londonderry, 1843, p. 363 (non Goldfuss, nec Binney).
„ „ M'Coy, Synop. Carb. Lime. Foss. Ireland, 1844, p. 170.
„ sp., Dawson, Quart. Journ. Geol. Soc. 1845, i. p. 326.
Microconchus, Bronn, Index Pal. Nomen. 1849, p. 725.
Spirorbis carbonarius, Binney, Mem. Lit. and Phil. Soc. Manchester, 1852, x. p. 196, t. 2, f. 3.
Gyromices ammonis, Göppert, in Germar's Verstein. Steinkohlen. von Wettin u. Löbejün. 1853, heft 8, p. 29, t. 39, f. 1-9.
Serpula carbonaria, Morris, Cat. Brit. Foss. 1854, 2nd ed. p. 92 (non Binney, nec Giebel).
Spirorbis carbonarius, Dawson, Quart. Journ. Geol. Soc. 1854, x. p. 39.
Gyromices ammonis, Geinitz, Verstein. Steinkohl. in Sachsen, 1855, p. 3, t. 35, f. 1-3.
Spirorbis carbonarius, Eichwald, Bull. Soc. Nat. Moscou, 1856, No. 2, p. 407.
Spirorbis pusillus, Eichwald, Lethæa Rossica, 1860, i. p. 670.
„ *carbonarius*, Salter, Iron Ores Gt. Brit. 1861, p. 226-7, t. 2, f. 23,
Gyromices ammonis, Geinitz, Dyas, 1862, heft 2, p. 133, t. 35, f. 2 and 2*a*.
„ „ Lesquereux, American Journ. Sci. 1861, xxxii. p. 195; *id. ibid.* 1862, xxxiii. p. 208.
Spirorbis carbonarius, von Roehl, Nat. Hist. Vereins d. Preuss. Rheinl. Verhandl. Dorpat, 1864, xxi. p. 43.
„ „ Binney, Trans. Manchester Geol. Soc. 1866, vi. p. 42.
„ „ Lesquereux, Illinois Geol. Survey Rept. 1866, ii. p. 462, t. 38, f. 6*a* and *b*.
Palæorbis ammonis, van Beneden et Coemans, Bull. l'Acad. R. Bruxelles, 1867, 2me. ser. xxiii. p. 390, plate f. 1-4.
Spirorbis carbonarius, Murchison, Siluria, 1867, 4th ed. p. 302, foss. 83.
„ „ Dawson, Acadian Geol. 1868, 2nd ed. p. 182, f. 31*a*, p. 205, f. 47.
„ „ von Roehl, Foss. Flora. Steinkohl. Westphalens, 1868, lief. 1, p. 4, t. 16, f. 4. A.A.
Gyromices ammonis, Schimper, Traité de Pal. Veg. 1869. i. p. 144, iii. p. 562, Atlas, t. 1, f. 15*a* and *b*.
Spirorbis carbonarius, Peach, Trans. Geol. Soc. Edinb. 1871, ii. pt. 1, p. 82.
„ „ Lyell, Student's Elements of Geol. 1871, p. 386, f. 431 *a* and *b*.
„ „ D. Jones, Trans. Geol. Soc. Manchester, 1871, x. pt. 1, p. 37.
Palæorbis ammonis, Goldenberg. Fauna Saræpont. Foss. 1877, heft 2, p. 4, t. 2, f. 32 and 33A.
Spirorbis carbonarius, Miller, Cat. American Pal. Foss. 1877, p. 207.
„ „ Etheridge, jun., Quart. Journ. Geol. Soc. 1878, xxxiv. pp. 3 and 9.
„ „ Dawson, Acadian Geol. 1878, 3rd ed. p. 182, f. 31*a*, p. 205, f. 47.

[1] Lethæa Rossica, i. p. 668. [2] *loc. cit.* p. 43.
[3] Proc. Nat. Hist. Soc. Glasgow, iii. p. 329.

Sp. char.—Tube dextral, irregularly planorbiform, varying from 1 mm. to 3·5 mm. in diameter; volutions convex, $1\frac{1}{2}$ to 3, not all in the same plane, sometimes protruding on the attached side, so that more are visible on that than on the free side, but at other times flattened and even grooved; occasionally prolonged into a short free tube. The last volution either expands towards the aperture, when the latter has a somewhat sigmoidally curved margin, or it is sometimes prolonged into a short free tube, when the aperture is circular, and inclined a little to one side; general section of the tube circular; umbilicus well marked, but not exposing more than the first two whorls or volutions of the tube. Surface sometimes nearly plain, but more usually ornamented with close, regular, direct, transverse microscopic striæ or ridges, which vary in their degree of strength, with occasionally one coarser and stronger than the others; at times fine spiral striæ are present.

History.—In 1809 Mr. W. Martin described what he then took to be a small shell incrusting plant-remains preserved in an ironstone nodule from Chesterfield, under the name of *Conch.* (*Helicites*) *pusillus*,[1] and which he defined as a depressed, smooth, umbilicated, firmly-coiled shell, consisting of three round and tapering volutions, and with a subrotund aperture. From the general appearance of Martin's figure, there can be little doubt that we have here the organism afterwards described by Murchison as *Microconchus carbonarius*,[2] and first incidentally mentioned under this name as early as 1836 by the late Prof. J. Phillips,[3] as occurring in the Ardwick limestone, near Manchester.

The late Sir R. Murchison, in describing the fossil contents of a "freshwater limestone" in the Shrewsbury Coal-field, proposed the name *Micro. carbonarius* for a "very minute discoid univalve," without any trace of chambers, and of which he gave figures of all the varieties noticed by him. This be it noted without any reference to Martin's figure, of the existence of which he was probably unacquainted. Murchison's illustrations exhibit the various varieties of the *M. carbonarius*, both in the form of the mouth and surface ornamentation, and further that one of the specimens had been attached to some object smaller than itself, leaving a groove across one surface. On another page[4] Murchison quotes a letter from Prof. Phillips, who refers to the same little shell from the Manchester, Yorkshire, and Newcastle Coal-fields. He remarked that the volutions "touch one another like *Planorbis* when young, but when old are extended into a free tube as in *Vermetus*, or rather like *Vermilia*. The shell is sinistral like *Planorbis*, but sometimes shows proof of being attached on one side like *Spirorbis*. Lines of growth strong, somewhat irregular, deficient in parallelism, and oblique to the axis of the tube as in *Planorbis;* faint spiral striæ can just be seen."

At the time Sir R. Murchison and Prof. Phillips were engaged on their investigations just referred to, Dr. Hibbert was conducting his examination of the Burdiehouse limestone, and he found therein

[1] Petref. Derb. 1809, t. 52, f. 2 and 3. [2] Silurian Syst. 1839, p. 84, fig. D1–10.
[3] Brit. Assoc. Rept. for 1836, pt. 2, p. 87. [4] *loc. cit.* p. 88.

minute shells with a "sort of spiral organization by no means unlike that of the *Planorbis* or *Spirorbis*."[1] The figure which accompanies this short description renders it quite clear that the body found by Hibbert, called by him a *Nautilus*, could be no other than those to which Murchison applied the name *Micro. carbonarius*.

Dr. Hibbert's figure of the *Nautilus* was reproduced shortly after its publication by Mr. W. Rhind in a little work entitled, "Excursions illustrative of the Geology and Natural History of the Environs of Edinburgh,"[2] without comment or further information. In the 1st edition of his "Catalogue," Prof. J. Morris united the *Helicites pusillus*, Martin, and Murchison's *Micro. carbonarius*, and placed the species in the Gasteropoda.

In 1843 Col. Portlock recorded[3] the occurrence of two forms of *Spirorbis* in the Irish Carboniferous rocks, *S. omphalodes*, Goldf., and *S. minutus*, Portlock. Of the first it is said, "they are fixed on the compressed stems of *Calamites*, and if removed, are found to have made a well-marked impression on them." The second species is said to resemble the first in general form, "but are so minute and crowded together as to appear like a fine granulation on the crust of *Dithyrocaris Colei*." I shall have occasion to make some remarks on these forms further on under the subdivision "Observations." Following Portlock, we have, in 1844, Prof. M'Coy,[4] who quotes both the preceding species, but places a note of interrogation after the determination of *S. omphalodes*, Goldf. He says, "On certain shale plants are found abundance of a little shell referred by Captain Portlock to the above species. The Irish specimens are perfectly flat on the attached side, smooth, and having two and a half or three turns in the spire; the mouth semicircular."

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

V.—On the Artificial Production of the Perlitic Structure.

By Grenville Cole,

Demonstrator in the Geological Laboratory of the Royal School of Mines.

VARIOUS investigations of the Perlitic structure in igneous rocks have resulted in its being regarded as a product of unequal contraction in a cooling mass of lava. Professor Bonney, in a paper on Columnar, Fissile, and Spheroidal Structure,[5] has compared it to the roughly-concentric joints to which, in certain basalts, the spheroidal character is due; and Mr. S. Allport, in his account of certain Ancient Devitrified Pitchstones and Perlites,[6] writes that "an examination of all the facts leads to the conclusion that the perlitic texture is purely a phenomenon of contraction." Of this, then, there has practically been no doubt; but, so far as I am aware, the structure has not until recently been imitated by artificial means.

[1] Trans. R. Soc. Edinb. 1866, xiii. p. 151.
[2] 12mo. 1836, p. 35.
[3] Geol. Rept. Londonderry, etc., 1843, p. 363.
[4] Synop. Carb. Lime. Foss. Ireland, 1844, p. 170.
[5] Quarterly Journal of the Geological Society, vol. xxxii. p. 149.
[6] Ibid, vol. xxxiii. p. 451.

While preparing microscopic sections in the Geological Laboratory of the School of Mines, I accidentally touched with wet fingers the square of glass on which a specimen for grinding was becoming set in stiff Canada balsam. This balsam had been somewhat over-heated, and had been left to harden for about a minute. The sudden cooling consequent on the contact developed a series of cracks throughout its thicker portions, and these in all their details correspond to the perlitic structure.

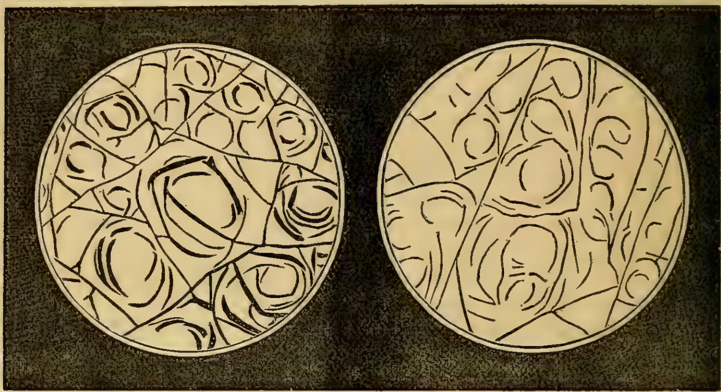


Fig. 1.—Perlitic Structure produced in Canada balsam by rapid cooling.

Fig. 2.—Section of Perlite from Hlinik, near Schemnitz.

The formation of the secondary or curved contraction-cracks has indeed extended farther than in many natural perlites, four or five segments within one another being not uncommon in this artificial specimen. A series of fairly rectilinear joints separates the groups of curves, the general character being best shown by the accompanying figure. A section of a natural perlite, drawn to the same scale of enlargement, is given for purposes of comparison.

Subsequent experiments show that the rectilinear series may be produced easily enough by rapid cooling; but it is only when the conditions allow a farther contraction to take place that the sets of curves are formed between them. The procedure has been in later instances to lay the thoroughly-heated slide on a china plate containing a thin layer of water, taking care that the balsam itself remains exposed to the air alone. The cracks speedily develope, being in some cases exceedingly regular in their characters.

As usually happens, no intentionally-produced result has as yet approached in completeness that accidentally attained; but I have no doubt that, after some attempts, a good typical specimen of perlitic structure might be procured.

The frequent superior breadth and blackness of the concentric segments may perhaps be attributed to their being portions of actual spheres, and in several places their two bounding edges require a different adjustment of focus under the microscope.

As rapidity of cooling appears to be essential to their production, it may perhaps be inferred that a similar condition has limited the natural perlites. In that case, it is suggested that a gradual passage from the complete structure on the surface to the existence of the rectilinear cracks only, and finally to the unbroken glassy magma at the centre, might be traceable in the perlitic masses of the field; and it would be of interest to learn from geologists who have opportunities for such study whether a gradation of this kind actually occurs.

VI. — Some New Points in the Pre-Cambrian Geology of Anglesey.

By C. Callaway, M.A., D.Sc. London, F.G.S.

With Notes on some of the Rocks.

By Prof. T. G. Bonney, M.A., etc.

RECENT researches in Anglesey, made with a view to assist my investigations into the Pre-Cambrian rocks of Shropshire, have led me to certain results, some of which I now submit to the geological public. In venturing to differ, in some respects, from so high an authority as Prof. Ramsay, I wish to bear testimony to the great value of his descriptions of the Anglesey rocks in his magnificent work on the Geology of North Wales. I have had the satisfaction of finding that Prof. Bonney's determination by the microscope of some of the more difficult rocks substantially agrees with my own opinion formed on hand specimens, and am under great obligations to him for permitting me to append his notes to this paper.

The term "gneiss" is restricted in this article to a schistose compound of quartz, felspar, and mica or hornblende, and is not applied to a rock in which foliation is not quite distinct; the term "granitoidite" being employed for certain granitoid rocks for which the word "gneiss" has sometimes been used. Chlorite is common in the Anglesey gneiss, but it is hardly rash to infer that it is a decomposition product of hornblende or a magnesian mica.

A.—Evidence of Pre-Cambrian Age.

It is well known that the Survey has mapped the schistose rocks of Anglesey as metamorphic Cambrian and Silurian, with a great granite band of intrusive origin; but recently the clastic origin of this "granite" has been maintained by Prof. Bonney after microscopic examination, and that author and Dr. Hicks are of opinion [1] that the rock is contemporaneous with the Dimetian of Twt Hill and St. Davids.

Of the accuracy of these views I have no doubt, and I am able to furnish confirmatory evidence on both points. First, as to the clastic origin. North of the Holyhead Road, north-west of Gwalchmai, is a faulted mass of the granitoidite with a steep escarpment to the south-east (Fig. 4). The lower part of the scarp is a bedded breccia, containing fragments of a sort of hornstone. It dips at a high angle to the north-west, and passes up into granitoidite with distinct bedding, which, in its turn, passes up into the ordinary

[1] Quart. Journ. Geol. Soc. vol. xxxv. pp. 302 and 307.

amorphous type. At many points round Llechyn farwy and Llandrygarn, as will be shown in detail, the granitoidite is clearly interstratified with schist, and passes into it both horizontally and vertically. As confirming the identity of the Anglesey and Twt Hill granitoidite, the following fact is of importance. Messrs. Bonney and Houghton[1] have detected at Twt Hill a passage between the granitoidite and a quartzose conglomerate with a south-east dip. I have visited this section, and, having examined the rock inch by inch, I can entirely confirm their identification. There are no signs of a fault between the granitoidite and the conglomerate, and the transition between the two is gradual and unbroken. I have had the good fortune to discover this identical conglomerate in Anglesey. It is exposed in two quarries near Nebo, two miles south-east of Amlwch, dipping to the north-west at a high angle. Lithologically it is perfectly indistinguishable from the Twt Hill rock; the quartz has the same glazed surface, both conglomerates contain disseminated crystals of cubic pyrites, and are tinged with the same dingy purple colour. I could find no granitoid rock in these quarries, but the ordinary granitoidite occurs on about the same strike, one-third of a mile to the north-east. That this conglomerate is not Cambrian or Ordovician[2] is proved by the fact that in these quarries black Ordovician (Carodoc or older) shales rest upon its upturned edges. It is also associated with bands of quartzose grit as in the Twt Hill locality.

The sedimentary origin of the granitoidite being proved, it remains to demonstrate that it is of Pre-Cambrian age. The unconformity between the Ordovician group and the conglomerate of Nebo, just noticed, might perhaps be considered decisive of the question. If this be denied, we are thrown back upon the hypothesis that, between the Cambrian and the Caradoc periods, the older series was metamorphosed into granitoidite and schist, tilted up at a high angle, and largely denuded. This, I presume, no geologist will maintain. The evidence from included fragments also tends in the same direction. Prof. Bonney[3] noticed a pebble of the granitoidite in the Cambrian conglomerate of Llyn Padarn, and I have since observed that such inclosures are not uncommon. Prof. Ramsay furnishes similar testimony.[4] He describes the "Silurian" conglomerate of Anglesey in the following terms:—"The pebbles of the conglomerate are sometimes six or eight inches in diameter, and, taken from different places at random, they consist of white quartz, grey quartz-rock, mica-slate, green schist, jasper, purple slate, a granitic rock of quartz and felspar with sometimes a little mica, blue felspathic trap, dark green hornblende rock, and chlorite." I have seen this conglomerate in several localities, and could in all material points confirm, were it necessary, the above description. All of the varieties named occur in the metamorphic groups of Anglesey.

[1] Quart. Journ. Geol. Soc. vol. xxxv. p. 322.

[2] I have adopted Mr. Lapworth's name (Geol. Mag. Jan. 1879) for the rocks called "Lower Silurian," that is, the groups from the Arenig to the Caradoc inclusive.

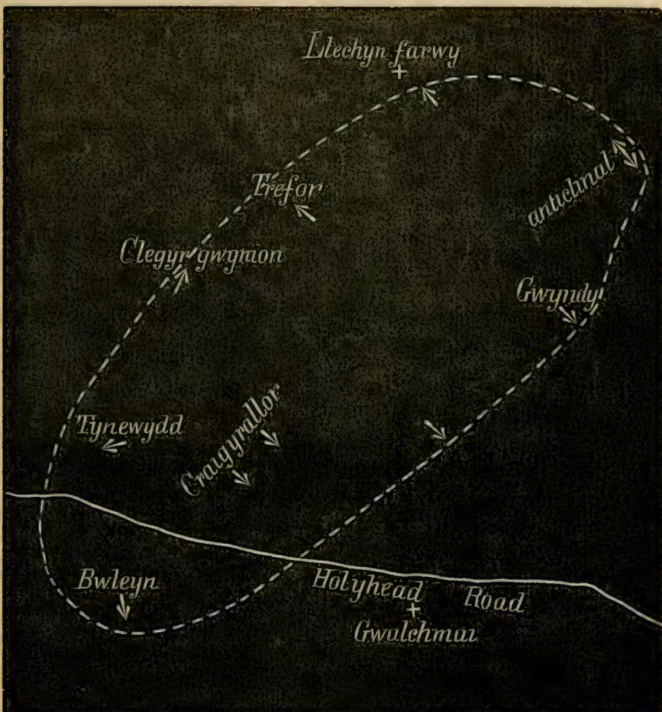
[3] Quart. Journ. Geol. Soc. vol. xxxv. p. 316.

[4] Geology of North Wales, p. 195.

B.—Continuity of the Granitoid Series with an underlying Gneiss.

(*a*). *The Craig yr Allor anticlinal.*—Dr. Hicks[1] states that the Dimetian granitoidite is the "base-line or axis" of the Pre-Cambrian rocks of Anglesey. From this conclusion I am compelled to differ. I do not here discuss the details of the group or groups which underlie the Dimetian: I am only concerned to prove that it passes down without a break into a great schistose series. The

Fig. 1.—Plan of the Craig yr Allor anticlinal.
Scale: One inch to the mile.



The arrow-marks indicate dips of dark gneiss. The dotted line is the boundary between the gneiss and the granitoidite.

evidence of this statement is absolutely complete. In the very centre of the granitoid "axis," rises a dome of dark gneiss, throwing off the granitoidite in all directions, and passing up into it through beds of an intermediate lithological character. This dome is elliptical, and is three and a half miles long by about one mile and a half broad, its larger diameter striking north-east in agreement with the general strike of the district. It lies mainly north of the Holyhead Road, and is represented, in part, by the patch coloured as

[1] Quart. Journ. Geol. Soc. vol. xxxv. p. 302.

"Altered Cambrian," surrounded by "granite," on the Survey Map. The most southerly point in this area at which I have observed the schist is at Ty newydd, half a mile south of the Holyhead Road, and it disappears under the granitoidite at the north-east extremity of the ellipse near Seri fach, one mile and a half east of Llechyn farwy, in the very centre of the granitoid band. Its axis lies a little west of the craggy ridge of Craig yr Allor.

Proof of the Anticlinal (Fig. 1).

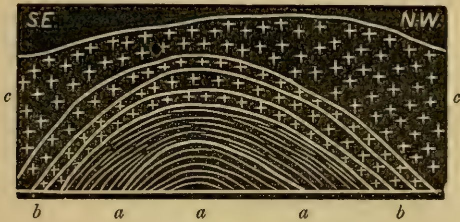
Commencing at the south end, we find at Bwleyn, north-west of Llanbeulan, quartzose chloritic schist with a high S.S.E. dip. At Ty newydd, one-third of a mile to the west, the rock is similar. Coming round to the north-west to the north of the Holyhead Road, we find, at another Ty newydd (Note 1, p. 126),[1] an exposure of dark gneiss with folia planes dipping at a low angle to the W.S.W. A mile to the N., at Clegyr gwynion, I obtained the first clear proof of the infraposition of the schist. Approaching the farm, the foliation lines are seen striking to the S.E across the road. Climbing the wall to the right, I came upon a projecting crag composed of dark gneiss, very micaceous, interstratified with thin bands of nodular granitoid (Note 2, p. 126) rock. About three yards to the N.E. is another boss composed of similar material; but in this case the thin bands are of schist, the rock being mainly granitoid. The dip in these passage beds is at a moderate angle to the N.E. A few yards further on is a large craggy mass of granitoidite, in which I could detect no schistose intercalations. These rocks, it will be seen, show a deviation from the normal N.W. dip, and this is not the only locality in which I have noticed that the dome is disturbed or fractured. This is, of course, precisely what was to be expected in such a shattered district as Anglesey. Four hundred yards to the E., the gneiss dips to the N.W. A little further to the N.E. is contorted dark gneiss, with broad quartzo-felspathic folia dipping at a low angle to the N.W. and N.N.W. Higher beds, the strikes of which are seen at the junction of the two roads S. of Trefor, display the normal N.W. dip. Here also are seen nodular bands of granitoid rock. A mile N.E. of Trefor, E. of Llechyn farwy, hornblendic and micaceous schists are well exposed, dipping at a high angle to the N.W., and passing up through nodular passage beds into the granitoid rocks seen N. of the church.

Coming round to the N.E. end of the dome, we find the very apex of the anticlinal. This is seen about a mile S.E. of Llechyn farwy, at the second "e" of Pentre'r felin in the Ordnance Map, in a field E. of the road. The beds are bent into a perfect arch, and are composed of alternations of coarse and fine-grained dark-green gneiss, with a granitoid band in the middle. The axis of the anticlinal is seen to trend to the N.E. Granitoidite lies a few yards to the E. Following the axis to the N.E., we find in a quarry by a farm the

[1] The numbers within brackets refer to Prof. Bonney's appendix (pp. 125–126). This rock looks like a hornblende-gneiss, but Prof. Bonney considers the dark mineral a mica. A great part of the upper gneiss seems hornblendic, but I have generally used the term "dark" throughout this paper, in deference to his opinion.

highest beds of the schistose arch. The ordinary dark gneiss is overlain by a band of granitoid gneiss, a rock like granitoidite, but with hornblendic or micaceous folia developed in sufficient abundance to convert it into a true schist. This passage bed is overlain by ordinary granitoidite, which also lies in mass to the N.E.

Fig. 2.—Anticlinal N.E. of Pentre'r felin.



a = Dark gneiss. *b* = Granitoid gneiss. *c* = Granitoidite.

East of the anticlinal, the dip, exclusive of minor undulations, is regular to the S.E. The best section is seen to the S.E. of Gwyndy, which occupies a position corresponding to Llechyn farwy on the opposite side of the axis. Just opposite the junction of the two roads, green schist dips at a low angle to the S.E. This is overlain by passage beds (granitoid gneiss), which undulate for about 200 yards, and then plunge to the S.E. under massive granitoidite. Green schist appears at intervals to the S.E., but the band between Gwyndy and Bodwrog is mainly granitoid. Skirting the S.E. margin of the schist anticlinal, we find, about a mile S. of Gwyndy, the granitoidite resting on mica-gneiss; the latter dipping to the S.E. The junction is evidently a fault, for (1) there are no passage beds, (2) the mica-gneiss is not the summit of the schistose series, and (3) greenstone breaks up through the Dimetian a few yards to the E. of the junction.

Between the last spot and Bwleyn, the point from which we started, the ground is occupied by the broken ridge of Craig yr Allor. These rocks consist of black and dark-green gneiss, sometimes chloritic, dipping S.E. To the W. of the ridge, the gneiss is massive, and contains epidote. At one spot, unrounded fragments of quartzite are included, and weather out sharply on the surface. Granitoid concretions are not uncommon, composed mainly of felspar, with a little quartz and some chlorite. The Holyhead Road passes across the anticlinal, about half a mile S. of Craig yr Allor, and rocks of the ordinary types are exposed at intervals on both sides.

These details clearly show that the gneiss passes under the Dimetian to all points of the compass, and that it forms an elliptical quaquaversal anticlinal of Pre-Dimetian age. The presence of beds of passage wherever the section is unbroken is of great interest, proving that the Dimetian granitoid group is simply the continuation of an older series.

(*b*). *Section at Gaerwen in the Menai anticlinal.*—On the Survey Map, two bands of "gneiss" are indicated, the more easterly passing through the word "Caerwen," the other about half a mile west, at the great fault which brings down Permian rocks against the schist. I have run a section across this area from S.E. to N.W., with the following result:—

(1). At the windmill at "Caerwen." Chloritic mica-schist or gneiss with thick quartz folia. Strike N. and S. Dip vertical, or a little to the W. Small quarry a few yards N. of windmill. Hornblende-gneiss[1] (Note 3, p. 126), indistinguishable from a variety at Craig yr Allor, foliation planes N. and S., passing into a rock in which foliation is obliterated, and which therefore might easily be taken for diorite. The same passage is also seen in the Craig yr Allor area.

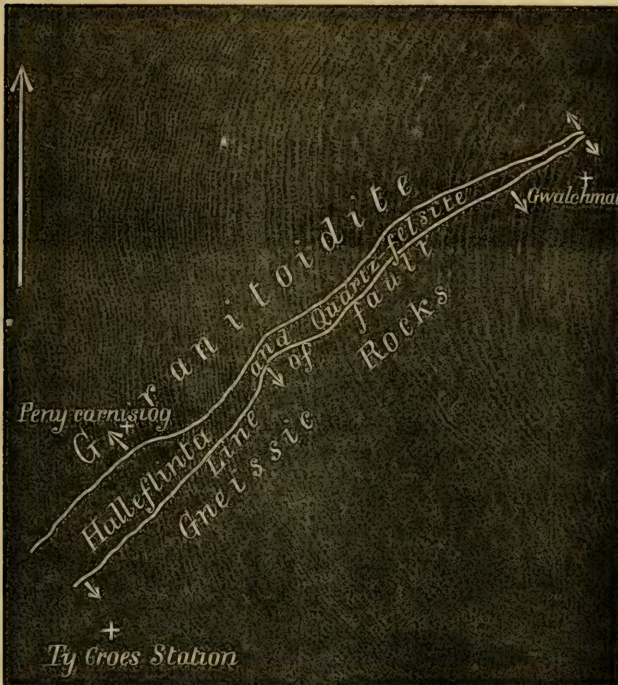
(2). At a quarter of a mile N.N.W. of (1), N.W. of "Post Office," is an exposure of grey quartzose mica-gneiss, with a high N.W. dip. This rock is continued for over a quarter of a mile to the N.W. It is well exposed at Bryn sisyr in a road section, where folia of pink felspar are very distinct. At this locality some of the schist is very quartzose. Further on, near Bryn disgwyl, the gneiss, very contorted, is exposed in quarries on both sides of the stream, and similar rock is seen in the road and fields nearly up to Y graig. The grey gneiss dips uniformly rather high to the N.W., and, if there is no repetition, it must be over 1000 feet thick.

(3). At Y graig, the dark-green gneiss comes in again, dipping N.W. at 50°. It includes, as in the Craig yr Allor district, some bands of a pinkish quartzo-felspathic rock, suggesting a transition towards the granitoid series: and contains a great deal of chlorite. It extends up to the Malldraeth fault (throwing down Ordovician shales and Carboniferous rocks), and is several hundred feet thick.

We have then two bands of dark-green gneiss, with a broad middle zone of grey gneiss, the whole dipping at a moderately high angle (say 50°) to the N.W., except at the base of the section, where the strike is N. and S., and the dip vertical or a little W. I have seen no reason to believe that there are two dark bands in the district. I am disposed to think that there is a repetition by folding, the anticlinal falling over to the east, so as to give a general westerly dip. The grey gneiss is not seen S.E. of Gaerwen windmill, and a little to the S.E., at Gaerwen station, we have chloritic schist dipping S.E. Granitoid rock is slightly exposed N.E. of Gaerwen, near Cefn du, but I was not quite sure that it was in place. Whether the repetition is by folding or faulting, or even if there is no repetition, my main conclusion is not affected, viz.:—that at Gaerwen we have a considerable thickness of grey gneiss passing up into dark gneiss, which in all respects resembles the dark gneiss of the Craig yr Allor anticlinal, and which may fairly be identified with that series. This section thus serves to bring the Pre-Dimetian gneiss of Craig yr Allor into relation with the schistose group W. of the Menai Straits, and proves that the dark gneiss is but the summit of a great gneissic series.

[1] It will be seen that Prof. Bonney considers this a diorite, though his determination is not very positive. There is apparent foliation in the rock, and I have left my observation to stand for what it is worth.

FIG. 3.—Plan of the group between Ty Croes and Gwalchmai.



Scale—one inch to the mile.

C.—ASSOCIATION OF VOLCANIC ROCKS WITH THE GRANITOID GROUP.

(*a*). *Section at Ty Croes.*—Dr. Hicks founds his Anglesey succession upon a section at Ty Croes.[1] Assuming the granitoid band as the base, he finds to the E. an exposure of hälleflinta, and this he places above the granitoidite, and calls "Arvonian." Further to the E., he comes upon green schist with an easterly dip, which he regards as the summit of the series, and identifies as Pebidian. To this order I am compelled to take serious objection.

In order to ascertain the true succession, I ran a series of sections in zigzags across the three zones, for six miles on the strike to the N.E. A few of the most decisive results are here given. I take the localities from S.W. to N.E.

At Pen y carnisiog, one mile N.E. of Ty Croes, the Dimetian clearly dips to the N.W., and one band of it passes up into quartz-felsite (Note 4, p. 125), without any line of separation.

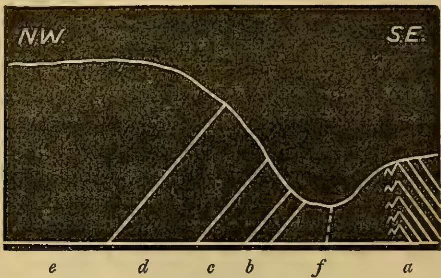
Between Ty Croes and this point, the "Arvonian" hälleflintas and quartz-felsites form a well-marked zone between the Dimetian and the schists. As the Dimetian dips to the N.W., it is difficult to see how the "Arvonian" can dip to the S.E.; and as bands of quartz-felsite of the "Arvonian" type are interstratified with the Dimetian,

[1] Quart. Journ. Geol. Soc. vol. xxxv. p. 302.

it is fair to conclude that the adjoining band of "Arvonian" dips in conformity with the Dimetian, and, therefore, below it.

One-third of a mile E. of Pen y carnisiog, in the "Arvonian" zone, hälleflinta, becoming rather granitoid at joint surfaces, is exposed. The "Arvonian" band is to be traced continuously for two miles further to the N.E., where, at Glanrafon, E. of Llanbeulan, it is represented by a well-marked quartz-felsite. The Dimetian and the schist (gneiss) have by this time approached much more closely.

Fig. 4.—Section two furlongs N.W. of Gwalchmai Church.



a=Schist. *b*=Felsite. *c*=Breccia. *d*=Bedded "G." *e*=Massive "G." *f*=Fault.

(*b*). *Section N. of Gwalchmai.*—One mile further to the N.E., four miles N.E. of Ty Croes, is a section which I regard as decisive of the true relations of the three groups. It occurs N. of the Holyhead Road, two furlongs N. of Gwalchmai. The "Arvonian" has almost disappeared, the Dimetian and the schistose series being separated by a hollow only twenty yards wide. To the E. of the hollow, grey gneiss is sharply contorted for two or three feet, and then it plunges to the S.E., in conformity with the uniform dip of the schist on this line of strike. To the W. of the depression, the Dimetian rises in a low, but steep, escarpment. At the base is a compact felsitic rock (Note 5, p. 126), with a horny fracture. Fine-grained granitoidite also occurs at the same level. Immediately overlying the felsite is a band of breccia, three or four feet thick. This bed is composed of horny-looking fragments, similar to the basement felsite, in a felsitic matrix (Note 6, p. 126). It clearly dips to the N.W. at a high angle, and passes gradually up into ordinary granitoidite, distinctly bedded, with the same dip; which, in its turn, passes up into the usual massive granitoid rock ("G" of the Survey), in which all traces of stratification are lost. Figs. 3 and 4 illustrate the preceding description.

This section proves that the Dimetian and the schistose group at this point are separated by a fault, for they dip steeply in opposite directions, the "Arvonian" has almost disappeared, and the schist is abruptly contorted at the junction. This dislocation undoubtedly runs to the S.W., and holds the same position in Dr. Hicks's section, throwing his "Pebidian" schists quite out of stratigraphical relation with his Dimetian and "Arvonian." That the schists are of Pebidian age is rendered still more improbable by the fact that they are mainly gneissic. The discussion of their true age does not belong to the present paper.

In the last section, we saw, still more clearly than at Pen y carnisiog, the intimate association of volcanic rocks with the granitoid group. In further illustration of this point, and of the occurrence of hälleflinta in the Dimetian, I will call attention to two more localities.

One mile north of the last section, between Ty newydd and Tyn rhos, quartz-felsite (Note 7, p. 126) is seen at more than one point, and in each case it passes by an imperceptible transition into the ordinary granitoidite (Note 8, p. 126).

Still further to the north, between Gwyndy and Pen y bonc, a thick band of hälleflinta is exposed in a road section. This bed is towards the base of the Dimetian, since, towards Gwyndy, the latter passes down into the dark gneiss.

Summary.

1. The granitoid (Dimetian) rocks of Anglesey pass down into an anticlinal of dark gneiss (above) and grey gneiss (below). The gneiss is also seen in the Menai anticlinal.

2. Low down in the granitoid series are bands of felsite, hälleflinta, and felspathic breccia, which can lay no claim to the rank of a distinct group (Arvonian).

3. The schistose series at Ty Croes is brought into contact with the principal quartz-felsite and hälleflinta band by a fault, and there is, therefore, no proof, from this section, that the schists are of Pebidian age.

VII.—Note on the Microscopic Structure of some Pre-Cambrian Rocks.

By Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S.

SOME repetition may be avoided in this note by roughly grouping the specimens, which have been forwarded to me by Dr. Callaway, as (A) Felsitic Rocks, or those resembling felstones; (B) Granitoid and Gneissic Rocks; and (C) Dioritic Rocks. The numbers attached correspond with the reference-numbers in Dr. Callaway's paper. I may mention that in examining the slides I was ignorant of their bearing on the views propounded by the author, and, in some cases, of the exact locality of the specimens.

(A).—Felsitic Rocks (4–7).

These are compact generally light-coloured rocks, breaking with a rather sharp fracture, and weathering to a pale, whitish tint. The ground-mass of each consists chiefly of microcrystalline quartz and felspar, of very indefinite outline and arrangement, in which occur some larger grains of the same minerals, with more or less opacite and other microlithic minerals. The ground-mass of (4) exhibits a wavy graphitic or almost arborescent structure not uncommon in felsites.[1] The larger quartz and felspar grains are generally ragged

[1] Described by myself, Geol. Mag. 1877, Dec. II. Vol. IV. p. 508.

at the edges; though the latter are sometimes in part bounded by straight lines. In these, and occasionally in the ground-mass, are minute scales of a clear mica. The quartz is very clear. Magnetite (with some hæmatite) may be recognized. Part of the slide exhibits a brecciated structure, but after careful examination I am of opinion that this is due to brecciation *in situ*;[1] and that the rock is a *quartz-felsite.*

(5) Differences only varietal, ground-mass less "arborescent" in structure, less porphyritic, no mica, but a minute granular pale-green (hornblendic?) mineral. Less brecciated; also a *quartz-felsite.* The structure suggests the possibility of its being a contemporaneous lava. (6) Structure of ground-mass yet more minute and granular; parts of the slide show a distinctly clastic structure, which it is very difficult to suppose the result of brecciation *in situ.* In any case, I believe the rock the result of volcanic action; and think it most probably an altered *trachytic tuff.* (7) Ground-mass nearer to that of first two; but more minute in structure. Outlines of quartz and felspar more regular than in (4); former mineral less "clean." Numerous almost colourless microliths in the ground-mass. Rather brecciated, but as the structure much more resembles that in (4), I think the rock a true *quartz-felsite*, possibly once a lava flow.

(B.)—Granitoid and Gneissic Rocks (2, 8, 9).

These three rocks consist mainly of quartz, felspar, and mica, and are very granitoid in aspect, exhibiting no distinct foliation. Still the outline and arrangement of the component minerals suggest that they are metamorphic rather than true igneous rocks. (2) Quartz rather full of minute cavities. Among the felspar, a considerable amount plagioclastic. Microliths frequent; probably decomposition products; green mica (biotite) and a little white mica. A *granitoidite.* (8) The specimen is not a favourable one for examination, being taken (probably unavoidably) from an old surface. At the first glance it seems indubitably clastic, but closer examination shows that much of this structure has been produced *in situ*; crystals of felspar being broken through and recemented by vein quartz, etc.; so that we cannot cite it as a proof of clastic origin for the rock itself. Still so far as the true structure of this can be ascertained, it is that of a *granitoidite,* rather than a true granite. Some of the felspar is orthoclase; there is also finely banded plagioclase, and perhaps a little microcline—a good amount of opacite and ferrite, and a little of a clear micaceous mineral, similar to that already described in rocks of this kind.[2]

(C.)—Diorite.

(3) In this specimen the felspar is a good deal decomposed; the hornblende is green, showing good dichroism and characteristic cleavage, but is more or less irregular in external form. Ferrite, opacite, and larger grains of some iron oxide present. A trace of a

[1] Produced by crushing or strain: not uncommon near faults.
[2] Quart. Journ. Geol. Soc. 1879, vol. xxxv. p. 322.

plagioclastic felspar is here and there to be recognized; the hornblende very irregular in outline. I believe, however, that we may safely affirm the rock to be a true *Diorite*. There is a fair quantity of a pale yellowish-brown somewhat earthy-looking mineral, with a fairly-marked prismatic cleavage; occasionally in well-defined crystals, which from their outline and optical properties appear to be monoclinic: microlithic crystals, apparently of a similar mineral, are often contained in them. They may be epidote, but are not in that case characteristic examples; they have also some resemblance to sphene.

REVIEWS.

I.—A Manual of the Geology of India, etc. (Second Notice, continued from the Geol. Mag. for February, 1880, p. 85.)

Strongly contrasting though the several formations are which make up the two great groups of the Peninsular and Extra-Peninsular rocks—they are yet found in a few places to be in actual juxtaposition, individual members of each group occurring outside the geographical limits of the two areas:—for example, in Cutch and Kattywar, certain marine Extra-Peninsular beds are interstratified with typically Peninsular formations. Again, in Sind, a representative of the Deccan trap occurs intercalated between the marine Eocene and Cretaceous rocks.

Two other Extra-Peninsular localities are named by the authors, in which Peninsular rocks are found. "One of these is at the base of the Himalayas, in Sikkim and Bhután, where fossiliferous Damúda (Lower Gondwána) beds occur. The other is in the Assam Hills (Khási and Gáro), where representatives of the metamorphic and Cretaceous (marine) rocks of the peninsula, and in all probability of the transition beds, and of the Rájmahál traps, are found. But in the first instance the relations between such Himalayan rocks as are associated with the Damúdas and those of other parts of the Himalayas are extremely doubtful; and it is not even conclusively settled whether the Himalayan rocks in question are higher or lower in position than the Damúda beds themselves; and in the Assam hills none of the older Himalayan formations have been detected; they appear to be replaced by Peninsular types" (p. xv).

A very interesting and important point of contrast between the two great areas, and one throwing great light upon their geological history, is to be found in the absence of any traces of disturbance in late geological times in the Peninsular area; "a feature which (as Mr. Blanford pointedly remarks) abruptly distinguishes the whole area from the remainder of Asia" (p. vi). He contends that the principal dividing ranges of the Peninsular area "are merely plateaus, or portions of plateaus, that have escaped denudation. There is not throughout the length and breadth of the Peninsula, with the possible exception of the Arvali, a single great range of mountains that coincides with a definite axis of elevation; not one, with the exception quoted, is along an anticlinal or synclinal ridge. Peninsular India is in fact a table land worn away by subaerial denudation, and perhaps, to a minor extent, on its margins, by the sea" (p. v). This absence of evidences of disturbance in the Peninsular area shows that during long periods following the early Palæozoic times conditions of remarkable permanency and quietude prevailed. A similar condition of but slight, if any disturbance seems to have existed in the Extra-Peninsular region also, till the advent of the Tertiary epoch, but later on periods of great disturbance supervened.

To turn now to the several formations, which want of space compels us to treat very cursorily, and to begin with the metamorphic rocks—we learn from the Manual that, although no relations between the oldest Himalayan rocks of this group and the Gneiss of the Peninsula can be determined — no contact section of the two formations being known—a well-marked mineralogical distinction exists between the two. "The contrast between the Peninsular and Extra-Peninsular regions begins thus with the oldest known rocks; but it is evident that the limits of the areas were then different from what they subsequently became."

The Transition or sub-metamorphic rocks, which "consist of schists, slates, quartzites, breccias, limestones, etc.," are stated to be of great thickness, and to occupy a considerable area, "but their history is as obscure as is that of the Gneiss. Two great subdivisions are recognized, which are again divided into several groups, "distinguished as much by locality" as by mineral characters.

The first of these subdivisions shows partial metamorphism, and otherwise, also, a close connexion with the Gneissic rocks; it is therefore thought to be older than the other, which does not show such conditions. There seems very good ground for believing that some of the Transition beds were deposited "previously to the last great disturbances that affected the strata of the Peninsula; whilst later beds, when tilted or contorted, are only affected within limited areas. Faults of considerable magnitude have certainly been formed at a subsequent period; but still the great lines on which the rocks of the peninsula have been moulded were more than traced before the transition epoch had passed away" (p. xx). There is probably much truth in the statement that "It is far from improbable that great mountain ranges were formed in the Indian Peninsula before the dawn of geological history, as recorded by organic remains; and that the small ridges of metamorphic and transition rocks now remaining are but the remnants that have escaped denudation" (p. xx).

The principal representatives of the lower subdivision are the Bijáwars, Champanir, Arvali, Malani and Behar groups in the Peninsular area, and the Shillong group in the Extra-Peninsular area, south of Assam.

To the upper subdivision of the transition rocks belong the Gwalior Series of the North of the Peninsular area, the Kaládgi Series of the South Mahratta country, and the Kadapah Series of the Northern Carnatic, occupying three widely-separated basins.

When treating of the conditions under which the members of the Vindhyan Series, the uppermost of the Azoic Series, were deposited, Mr. Blanford is led (Introduction, pp. xxi–xxiii) to touch upon some interesting speculations as to the possibility of these rocks having been deposited prior to the dawn of animal life on the globe. He points out also that it is impossible to arrive at any safe conclusion as to the marine or freshwater origin of the series, no fossils having as yet been found in it.

The question as to the importance of the lapse of time indicated by the great break or unconformity between the Upper Vindhyans and the overlying Gondwanas is next discussed, and the conclusion arrived at that "the evidence is too uncertain to be accepted with much confidence, but, so far as it goes, it is in favour of the Vindhyans being classed as very ancient and, perhaps, as pre-Silurian."

The probability of the various local groups of the transition rocks having been deposited in isolated areas is also touched upon, and it is pointed out a great part of the country was therefore then over the sea, especially in the Upper Vindhyan epoch, and that the great break succeeding may indicate an "extensive and prolonged period of terrestrial conditions."

Indications of the early Palæozoic rocks must be sought for among the Extra-Peninsular rocks of the Punjab and Himalayas. The most southerly occurrence of Palæozoic rock is found in the Salt Range, one of the most interesting tracts, geologically speaking, in all India, and remarkable for its enormous wealth of rock-salt imbedded in the lowest series (locally exposed) of bright red marl with gypsum, which "in all probability is of Silurian age at latest." It is overlaid by several hundred feet of sandstones and shales, the latter containing a small Brachiopod closely resembling *Obolus*. At the western end of the Range the salt marl is directly overlaid by Carboniferous Limestone, with typical *Producti* and *Spirifers*. Similar limestones occur also in the Suleiman range, in Cashmir, and in the trans-Himalayan area far to the eastward. This proves the existence of a great break between the salt-marl and Carboniferous rocks. It is impossible to say more here about this tract, which is truly classic for Indian geology—the reader must refer to the Manual or to Mr. Wynne's admirably illustrated memoir on the Salt Range (Memoirs G. S. I.).

Much difficulty is found in correlating many of the unfossiliferous formations in the North-west Punjab and in the Western Himalayan region, and several of the determinations can only be accepted as provisional, though there is much probability of their being correct. Here and there a few reliable horizons have been settled by the discovery of fossils, as the Carboniferous beds of Kashmir, and perhaps the supposedly Silurian Bhábeh and Muth beds, of Dr. Stoliczka, in Spiti. Unquestionably Silurian beds occur to the North of Kumaon. If the supposition that the Attock Slates are really a continuation of the slates of Lahul, Kishtwar, and Kashmir, should prove true, and also that the latter rocks are representatives of the marine Silurian rocks of Spiti and Kumaon, a great step will have been taken in unravelling a difficult tangle in the skein of Himalayan formations.

The general plan of structure of the Western Himalayan region appears from the map to be really very simple: two great parallel gneissic axes, which run from north-west to south-east, bear on their flanks the Transition, Palæozoic and newer formations in approximately parallel bands. The northern of the two axes, known as the Ladak axis, runs about 50 or 80 miles from the southern or main axis, which constitutes the Himalayan range proper, and is probably continuous through the unknown regions of Nepal with the gneissic axis known in Sikkim. In the space between the two axes is the Hundes and Zanskar synclinal valley, which contains a great series of marine fossiliferous beds, in which all the principal formations recognized by geologists are represented, except the Cambrian, Devonian, Permian and Neocomian. For want of space, the question of the correlation of these beds and the unfossiliferous rocks of the Infra-Blaini, Blaini, Infra-Krol, and Krol beds on the south side of the main axis, cannot be more than alluded to. Quite lately the most conspicuous of these southern formations, the Krol limestone, has been claimed by Mr. Lydekker as representative of the Pir Panjál limestone, which is believed on fair evidence to be of Carboniferous age. "If this conclusion be true, the Cis-Himalayan strata of Simla are probably, in part at least, altered Palæozoic marine beds: although the absence of fossils, and the great petrological differences from the trans-Himalayan formations, have led to the suggestion that the Blaini and Krol rocks belong to the peninsular type. No definite connexion with peninsular rocks can, however, be made out." (Introduction, p. xxvi.)

The correlation of the formations constituting the mass of the huge Himalayan Mountain region is ably discussed by Mr. Medlicott, who divides his subject into three sections treating of the Sub-Himalayas, the Lower Himalayas, and Central Himalayas respectively. His extensive personal acquaintance with these regions gives a special value to his opinions in disputed questions, of which there are not a few.

A speculation of great interest, bearing on the former extent of the ancient Palæozoic continent of which the Indian peninsula doubtless formed a portion, deserves attention; it is put thus: "There appears some reason for inferring that the Palæozoic slates, sandstones and limestones, occupy hollows formed by denudation in the old gneissic rocks, and that subsequent pressure has produced the appearance of inversion" (of the gneiss over the younger beds). "If this be the correct view, it is probable that the Cis-Himalayan Palæozoic rocks are in great part of freshwater origin, and that the present crystalline axis of the Western Himalayas approximately coincides with the shore of the ancient Palæozoic continent" (p. xxvii). A similar suggestion has been made with reference to the Salt Range by Dr. Waagen, that it represents a part of the former limits of the Palæozoic peninsular continent.

The great Gondwana system, the Indian Coal-bearing series, is of such interest that it might well receive lengthened notice, but space admits only of very brief references to it. The Lower Gondwana beds are the oldest beds in the peninsula known to contain fossil remains, but none of these are marine, and all the groups, which consist of sandstones and shales and some beds of coal, appear to be of freshwater origin. The Upper Gondwanas appear also to be mainly of freshwater origin, but some marine beds are associated with them. "From a consideration of the facts known, the approximate age assigned to the Lower Gondwanas is Permian and Triassic, possibly a little older or a little newer, the evidence being by no means conclusive: the Upper Gondwanas are with more certainty classed as Jurassic" (p. xxviii).

"The area occupied by the Gondwana system is mainly confined to the country between the Narbada and Son to the north, and the Kistna to the south. The only outliers in the peninsula beyond the limits named are near the east coast, and on the westward in Kattywar, Cutch and Jesalmir, and consist of Upper Gondwanas only."

Among much valuable information given concerning the Gondwana system is a very interesting discussion as to the supposed relationship between the apparently fluviatile basins in which the Gondwana rocks occur and the valleys of the existing rivers, which was held by some Indian geologists to be very noteworthy; but this view is not favoured by the authors (p. xxviii et passim). The relation between the Gondwana series and the great Deccan traps is also treated of, and it is shown that "the vast tracts of Gondwana rocks now exposed in these areas owe their preservation in all probability to the protection from denudation afforded by the overlying traps." Especially interesting is the relation between the trap and Upper Gondwana beds in the Rajmahál hills.

The physical geography of the Gondwana period is briefly dismissed, as but little is to be said on the subject. The very contradictory relations of the Flora and Fauna are entered into fully, and are very well epitomized in the Introduction (p. xxxii). The plants of the Lower Series are Acrogens and Gymnogens; the former (Equisetaceæ and Ferns) being much more numerous, both in species and individually, than the latter, which consists of Cycads and Conifers. The plants of the Upper Series consist of the same classes in different proportion. Equisetaceæ have nearly disappeared, and Conifers and Cycads, the latter more especially, are more numerous than the Ferns. "The only formations in which plant-remains occur in abundance are the Karharbari, Damúda and Rajmahál, and even in these the number of species is comparatively far from great."

Of the three distinct floras in the Lower Gondwana Series, the lowest, the Talchir and Karharbari, has strong affinity to the lowest beds of the European Trias, but an equally close connexion with the Carboniferous (Upper Palæozoic) of Australia, a resemblance which is still much more striking in the succeeding Damúda group, some of the former being identical, and many closely allied. There is also a near agreement between the Damúda plants and the South African forms of the Karoo Series. "On the other hand, the affinity between the Damúda flora and that of any lower Mesozoic or Palæozoic group in Europe is comparatively small. Some Damúda plants are certainly allied to species found in Carboniferous, Permian, Triassic, and Jurassic beds, and perhaps the most marked connexion is with the Lower Oolites; indeed, the resemblance of a few plants in this case led to both the Damúda beds and the Australian being for a long time classed as Jurassic" (p. xxxiii). "However, there is a much closer alliance between the plants of the Lower Oolites and those of the uppermost Gondwana flora, and the latter is divided by an immense thickness of beds and several successive floras from the Damúdas."

The Fauna of the Upper Gondwana beds points strongly to a connexion with the South African Karoo beds by the presence, in the Mangli beds, of a Labyrinthodont closely allied to a Karoo type, and by the occurrence in the Panchet group, the uppermost of the Lower Gondwanas, of Dicynodont reptiles. The two Panchet Labyrinthodonts are most nearly related to European Triassic species. The Panchet flora, consisting of four species, shows two European Rhætic forms, the others being allied to Rhætic forms.

The Rajmahal (Upper Gondwana) flora is most nearly allied to the Rhætic, but is very peculiar, and differs much from any European flora. The Cutch and Jabalpur flora is Lower Oolitic in its own affinity, but overlies in Cutch marine strata of uppermost Jurassic age; while the fish-remains of the Kota Maleri beds, which, according to the plant-remains they contain, are intermediate between Rajmahál and Jabalpur, are themselves of distinctly Liassic affinities, and are associated with teeth of *Ceratodus* and remains of two characteristically Triassic reptiles, *Hyperodapedon* and *Parasuchus* It is, unfortunately, not possible to reproduce here all Mr. Blanford's arguments, but he arrives satisfactorily at the conclusion that India was united with Australia by land during the Lower Gondwana epoch, but not with Europe, the union with which took place later on; hence Lower Gondwana types found in European rocks occur at a later period. "Above the Lower Gondwanas the evidence of connexion with Australia is faint, and where any exists, it is perhaps on the whole in favour of a passage from India towards Australia."

The climates of India and South Africa also show evidences of similar condition, during the Lower Gondwana epoch, as both in the Talchir group and the Karoo series are beds of apparently glacial origin. These are interesting from their relative proximity in geological time to the Permian breccias of England, which are also supposed to be of glacial origin, and "combine to suggest the possibility of recurrent epochs of diminished temperature having taken place at intervals in the earth's history, and of one of these intervals having coincided with the Permian epoch."

The Gondwana series has been treated at very considerable length by Mr. Blanford, who has devoted no less than six long chapters to the full discussion of the facts and theories concerning the great plant-bearing series.

The age of the marine Jurassics on the east coast of the Peninsula has not yet been determined, except in one case in the Tripetty

Sandstones discovered by Mr. King near Cocanada. "The Cutch beds afford a very complete representation of all the European Jurassic beds above the Inferior Oolite; the Bath, Kelloway, Oxford, Kimmeridge, and Portland faunas being more or less clearly distinguished." The Upper Jurassics are represented in the Punjab and the Himalayas.

The Cretaceous rocks of India are of very small extent and topographical importance, compared with many of the older formations, but palæontologically they are very interesting, and the South-Indian beds yielded a wonderful harvest of fossils, especially Cephalopoda, which were mostly worked out by the lamented Dr. Stoliczka, and furnished him with materials for several great works published in the Palæontologia Indica. The three groups of Upper Cretaceous beds occurring in the neighbourhood of Pondicherry and Trichinopoly, and called respectively the Utatur, Trichinopoly, and Arrialur groups, correspond in age to the European beds ranging from the Upper Greensand, or Cenomanian, to the Upper Chalk, or Senonian. The lowest, or Utatur beds, rest unconformably on the plant-bearing Upper Gondwanas, or upon the gneiss. The formations are mostly littoral, and were deposited along a coast not differing greatly from the existing one, and lying, probably, not many miles to the west of their present western boundary.

A wide difference exists between the fossils of the Bágh Cretaceous beds in Central India, and as strong a resemblance between the latter and some European Upper Greensand beds, while a singularly close connexion existing between the South-African Cretaceous beds in Natal and the Trichinopoly and Assam beds points to the existence of a barrier of land cutting off the latter seas from the seas of Europe, Arabia (where Cretaceous rocks, with fossils of the Bágh type, occur on the south-east coast), and Western India. Very probably this may have been the same land which united India and South Africa during the Lower and Upper Gondwana eras

The chapter on the Cretaceous system gives full lists of the fossils so ably worked out by Stoliczka, from which it is seen that 16·36 per cent. of the newest strata (of which in all nearly 800 species are known) are forms known to occur in Cretaceous beds in Europe, the great majority of them being Middle or Upper Cretaceous. The Cephalopoda taken alone give a rather older aspect to the formation. The Cretaceous rocks of the South offer further confirmation of "the evidence already afforded by the Lower Mesozoic deposits, that the Indian Peninsula is a land area of great antiquity."

The geology of the great Deccan Trap series and its associated fossiliferous beds, though very interesting, must be dismissed with a few words. The great flows of lava are clearly shown to have begun at some time between the Middle Cretaceous and the beginning of the Lower Eocene, and to have been subaerial, not submarine nor sub-lacustrine. The known foci of eruption of the lavas are described and the characters of the infra-trappean, or Lameta beds, and of the inter-trappean beds, both freshwater and marine, are fully gone into lithologically and palæontologically.

Mr. Blanford places the high-level laterite in the Eocene series, and considers it of detrital origin; this may be the case with the beds in the northern parts of the great trap area, but along the southern parts all the evidence obtainable is strongly opposed to the idea of a detrital origin, and in favour of its being purely a product of decomposition of highly ferruginous trap flows. Till therefore the Survey of the central part of the trap area shall have been completed, it must remain doubtful whether the ferruginous rocks capping the uppermost trap flows at both ends of the area are really referable to one and the same formation.

The relations of the several members of the Eocene and newer Tertiary rocks of Sind, the Salt Range, the North-west Punjab, the Sub-Himalayan tracts, Assam and Burma, are fully discussed, and many points of great interest are well brought out; more especially the correlation of the Pliocene Siwalik fauna with the faunas of the equivalent rocks in Sind, Perim Island, the Narbada, and Irawadi valleys in the East, and the fauna of Pikermi in the West.

Of extreme interest are the speculations as to the distribution of the dry lands existing during these periods, and the effect upon the successive faunas and floras of India, of the connexions with Africa and the Malay Islands, also the inquiry into the series of upheavals which raised the Himalayas to their present vast height. Most of this upraising is shown to have taken place in Post-Pliocene times, and there are evidences that the volcanic forces are not yet extinct below the vast mountain chain.

By no means all the points of interest treated of in the Manual are even alluded to in the present notice; but as the limits proposed have already been far exceeded, we must now take leave of this great contribution to geological science, with hearty good wishes that it may be appreciated by the public as richly as it deserves to be. Every geologist will find it a work worth possessing, and many can afford to purchase it, its price (16*s.*) being absurdly low, and a marvellous contrast to the exorbitant charges which H.M. Stationery Office forces on the Geological Survey of Great Britain for its smallest publications.

R. B. F.

II.—Etudes Synthétiques de Géologie Expérimentale. Par A. Daubrée. Première Partie. Deuxième Section. Phénomènes Mécaniques. (Paris, 1879.)

The first section of this work, which deals with chemical phenomena, has already been reviewed in the pages of this Magazine, Vol. VI. p. 421 (September, 1879). In this second section the writer deals with the mechanical actions which have been developed during the earth's history, and applies the experimental method to their investigation. Though our means are even more disproportionate to the effects to be imitated in the case of mechanical than with chemical forces, still much light is thrown on various departments of Geological Science.

The first chapter is devoted to elucidating the formation of gravel, sand, and mud. Fragments of rock were rotated together with water, in horizontal cylinders of iron or earthenware. Their mutual friction soon reduced them to pebbles and fine mud. Sand is formed, but in subordinate quantity, and is usually angular; rounded only in exceptional cases. Quartz-sand, if derived from granite, is, M. Daubrée says, always angular. Each sand bears in some sort the stamp of its source and cause, and provides material for the study of former physical conditions. A section of this chapter discusses the distribution of gold in the bed of the Rhine.

The interesting chemical actions which presented themselves in these experiments were commented on in the review of the first section of this work.

The chapter concludes with an account of experiments on the striation of rocks. They were conducted by rubbing pebbles of quartz and felspar on plates of granite, with various pressures and velocities. By this means striæ could be perfectly imitated, and it appeared that neither high velocity nor high pressure were indispensable. Indeed, the velocity required for the commencement of striation seems to vary inversely as the pressure acting; so that striation depends on the product of the measures of pressure and velocity. An interesting observation is that under sufficient pressure softer rocks may striate harder.

The pebbles must be firmly fixed in order to engrave the plate of granite; if imbedded in a plastic mass such as clay, they slide and fail to scratch.

The second chapter, incomparably the most important and interesting, treats of the various deformations which the earth's crust has experienced, and the infinitely numerous fractures which subdivide it. These in their vast dimensions, their unlimited variety, might be expected to mock our feeble attempts at imitation of them. But Sir James Hall's classic experiments on the contortion of strata have commenced the work of explanation, and M. Daubrée, following in the same track, has provided a mass of materials for controversy. The first section of the chapter is devoted to folds and contortions, which are imitated by layers of metals, wax, etc., subjected to fixed vertical pressures, and acted on by gradually increasing longitudinal forces. If the vertical pressure be uniform, the folds produced are regular and symmetrical; but when the vertical pressures are unequal, the folding also ceases to be symmetrical. The contortions are most acute where the superincumbent pressure is least, as might be easily conjectured. Interesting illustrations show the growth of reversed folds, such as are well known in the Alpine Chain and elsewhere.

He then proceeds to discuss the nature and causes of faults, joints, and generally all kinds of fractures of the sedimentary rocks. Here we enter the battle-field of an ancient controversy, long waged with no decisive result, and perhaps even the powerful reinforcements which M. Daubrée has brought up may not be sufficient to secure a victory. If the origin of faults be not perfectly known, still few will now attribute them either to molecular actions, or to shifts in the position of the earth's equator—opinions which are alluded to as once held. But the cause of joints is still a dispute, wherein widely different views are maintained. Crystallization, or processes analogous to it, contraction, and mechanical strains, each have their various advocates. M. Daubrée marshals the whole array of his arguments and experiments on the side of mechanical actions. He adduces the generally uniform direction of joints over wide areas, and through varying rocks; the occasional distortion of the fossils in their neighbourhood (on the authority of Professor Harkness); and the well-known and significant fact that in many conglomerates they cut clean through pebbles and matrix alike, a fact difficult to explain on any hypothesis of contraction. Also he contends that faults and joints are connected by so many common characters, and graduate so perfectly into each other, that a common origin must be sought for them. The character in both on which most stress is laid, and towards which the experiments are most generally directed, is their arrangement in extensive parallel systems. Experiments imitating undulations gave no satisfactory result, but torsion and compression reproduced most of the peculiarities to be accounted for. For torsion, plates of glass were coated with thin paper and submitted to a wrench. Figures are given of the systems of fractures produced, which do in many respects recall the arrangement of systems of joints. Besides the visible fractures, systems of concealed planes of separation or weakness arise, which may be brought to light by the impulse of a shock, and answer to concealed joints or cleavage.

For pressure, blocks of a mixture of plaster and wax were longitudinally compressed by a powerful force. When the blocks had the proper degree of rigidity, after bulging a little, they yielded to the stress by the production of oblique fractures, and the consequent slipping gave rise to other fractures at right angles to the former. The ultimate results, shown in beautiful plates, and described at length, are some larger fissures making angles of 45° with the direction of pressure, systems of smaller crevices parallel to one or other of these, and yet other systems similarly aligned of cracks closed, invisible, and almost infinitely close and numerous. These are compared to larger and smaller faults, and joints and cleavage.

The obvious objection to the pressure-theory of faults is the old observation that they generally 'hade to the down-throw.' M. Daubrée answers that the exceptions are neither few nor unimportant; and that a horizontal shift can occasionally be proved by the directions of the slickensides. Probably he considers little disturbed regions as homologous to the bulges on his blocks, where the bulge must create ruptures by tension. He seems also to compare the fractures of such regions with the results of his experiments on torsion. In truth any irregular settlement of beds can scarcely fail to produce actions analogous to those of a wrench.

For pressure as a cause of joints there seems much to be said. If it be objected that joints ought in that case to show slickensides, M. Daubrée gives instances where they do. Besides, the motion which relieved the stress might well be so minute as to cause no visible displacement, just as in the production of columnar structure in igneous rocks, the contraction which has relieved the tension is often almost microscopic. The regularity and smoothness of joints agrees much better with pressure than with tension. The shearing stress of a pressure requires a plane face of rupture to permit the sliding which will relieve it, while a tension could be eased and ended by the opening of any crack, however irregular. It might also be alleged that contraction ought to produce hexagonal columns, or rhombohedrons and spheroids, while pressure, as in these experiments, developes rectangular blocks. However, Jukes mentions cuboidal jointing developed in certain cooled slags, which is clearly a consequence of contraction.

The sections devoted to the connexion of valley-systems with faults and jointing will scarcely satisfy physical geologists. But the maps and diagrams given are very interesting. The maps are ingeniously accompanied by superposed transparent diagrams of the general lines of water-flow. These do show a marked tendency to arrangement in two systems mutually at right-angles. Some evidence is given that there are systems of faults and joints parallel to these, but the proofs offered that certain valleys could not have been formed by erosion, without joints or faults to guide it, will hardly be considered conclusive. There is no allusion to the theory of rivers cutting their way across ridges in process of elevation. The cañons of Colorado are quoted as scarcely opened fissures.

M. Daubrée introduces the terms Paraclases to denote fractures with a throw; Diaclases for simple surfaces of separation; Lithoclases, to include both. The latter should surely be Petroclases, and there appears no distinction between the former terms and faults and joints respectively. Is it not a pity to coin new words unnecessarily?

Some experiments are described on the origin of indented pebbles, a phenomenon to which we remember no reference in English books, and some pretty figures are given of the mutual actions of a non-contractile envelope and a contracting nucleus. Systems of wrinkles are the result, answering to mountain chains on the surface of the earth.

While in the second chapter M. Daubrée treats of a controversy still active, in the third he takes up one generally regarded as set at rest. Sharpe, Darwin, Sorby, and Tyndall, have proved that slaty cleavage is due to lateral pressure. It is, however, not universally admitted that foliation is due to the same cause. M. Daubrée seems to consider them not only due to the same cause, but to be the same thing, and applies the single term "schistosité" to them both. It is well known that pressure has produced a laminated structure in some igneous rocks, and M. Daubrée's remarks on the production of foliated granite in a similar manner are well worthy of consideration. Instead of the fashionable belief in the metamorphism of sedimentary rocks into granite, he here appears to maintain the possible conversion of granite into gneiss.

But when M. Daubrée seeks to illustrate schistose structure by the texture of clay extruded under powerful pressure through an orifice, geologists will scarcely think this a representation of the common process in Nature. He remarks that in this case lamination is produced in the direction of the pressure, instead of at right-angles to it, as in the experiments of Sorby and Tyndall. But in truth their experiments produced the structure by pressure: these generate it only by flow. He remarks that a very small molecular motion is sufficient to develope the structure, but this does not seem obvious. The result which appears most interesting is that extreme pressure can produce in many apparent solids a kind of flow; so that there may be difficulty in distinguishing between the flow of a slightly viscous solid under powerful constraint, and the free motion of a body fluid from heat.

The discussion of the fan-structure in the Central Alpine gneiss is somewhat difficult to understand. In his experiments M. Daubrée seems to imply that the bedding was already vertical when formation of the fan-structure commenced. Yet it is not quite clear whether he does not consider the gneiss to have been extruded through rents in the superincumbent strata, as the clay in his experiment was extruded from the orifice in the press.

The last chapter gives the results of some experiments on the heat developed by crushing, grinding, and mashing clay, and in the mutual friction of rocks. As in the first section of the work it was argued that comparatively moderate heat might produce extensive metamorphism, so here the object is to show that such movements of strata as have been described could easily generate a heat which would be sufficient.

The second volume, which has just appeared, M. Daubrée devotes to "Cosmology," discussed mainly by aid of the phenomena of meteorites. E. H. (Cambridge).

III.—The Journal of the Royal Microscopical Society. Vol. II. Nos. 4–7, and Supplemental No. 7*a*. For June to December, 1879. 8vo. (London and Edinburgh: Williams and Norgate.)

SINCE our last notice (October, 1879) of this valuable periodical, the energetic Editor, Frank Crisp, with the assistance of other able Fellows of the Society, T. Jeffery Parker, A. W. Bennett, and F. Jeffrey Bell, has successfully carried out the improved plan of the Journal, and given to the scientific world a vast amount of original and derived information on the many subjects interesting to Microscopists, and therefore to Naturalists of many denominations. The contents of more than 300 serial publications, from all civilized countries, are laid before the readers of the Journal in a classified form every two months. On modern applications of the microscope to Geology there is a memoir by Fouqué in the "Revue des Deux Mondes," xxxiv., which is briefly noticed in the "Journal R. Microsc. Soc.," No. 12, p. 773; and at p. 459 the blackness of some weathered limestone and other rocks is referred to a *Protococcus* and *Lichen*.

Many of the zoological and botanical notices, among the excerpts and abstracts, of which there is a list occupying sixteen pages, have useful bearings on the study of palæontology; and in the rich bibliography many geological memoirs are noted. T. R. J.

IV.—A Monograph of the Silurian Fossils of the Girvan District in Ayrshire. By H. A. Nicholson, M.D., D.Sc., etc., and R. Etheridge, jun., F.G.S., etc. Fasciculus II. 8vo. pages 137–234, Plates X.–XV. (Edinburgh and London: Blackwood and Sons, 1880.)

The Girvan Monograph, aided by the Royal Society's grant, has special reference to the Silurian Fossils in Mrs. Gray's collection; and this second portion treats wholly of Crustacea—namely, the Trilobites that were not described in the first Fasciculus, some Phyllopods, Cirripedes, and Ostracods. Of *Trilobita*, altogether twenty-one genera are recorded as having been found in the Girvan District, and are described with their sixty-three more or less definite species. These are all illustrated in the plates, excepting some specimens mentioned by Salter and M'Coy, but now missing. Of *Phyllopoda* the following from Girvan are described:—*Solencaris solenoïdes*, J. Young; *Pinnocaris Lapworthi*, R. E. jun.; *Peltocaris* (?), sp.; *Dictyocaris* (?), sp. The *Cirripedia* are represented by *Turrilepas scotica*, R. E. jun.

The Silurian *Ostracoda* from Girvan are here described by Prof. T. Rupert Jones (pages 216–223, pl. xv.). They are referred to *Cythere Aldensis*, M'Coy, and var. *major*, Jones; *C. Grayana*, J.; *C. Wrightiana*, Jones and Holl; *Beyrichia Klœdeni*, M'Coy; *B. impendens*, J.; *B. comma*, J.; *Primitia Barrandiana*, J.; and *Entomis globulosa*, J.

The occurrence of these Crustacea in the several strata of the Girvan area is described in detail in the "General Remarks," pp. 223–233; and their geographical distribution is clearly shown by a large table. The descriptions are careful and exhaustive, enriched with conscientious references to other authors and comparisons of their results. The plates are good, except that pl. xv. appears to have been worn out or rubbed down too much.

This will be a very handsome work when finished, and cannot fail to prove of standard importance.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—January 21, 1880.—Henry Clifton Sorby, Esq., LL.D., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Genus *Pleuracanthus*, Agass., including the Genera *Orthacanthus*, Agass. and Goldf., *Diplodus*, Agass., and *Xenacanthus*, Beyr." By J. W. Davis, Esq., F.G.S.

The author commenced with an historical account of the supposed genera of fishes founded on remains occurring in Carboniferous and

Permian strata, mentioned in the title of his paper. The teeth described by Agassiz under the name of *Diplodus* have been already shown by Sir Philip Egerton to be associated with spines of the *Pleuracanthus*-type; and this identification was accepted by the author, who also showed that *Xenacanthus*, Beyrich, is identical with *Pleuracanthus*, and that, on the ground of priority, which there is no reason for disregarding, the latter name ought to be retained. With regard to *Orthacanthus* he indicated that in the type described by Agassiz the two rows of denticles are placed close together along the posterior face of the spine; while in his *Pleuracanthus* the denticles are situated as far as possible apart on the sides of the spine. In the new Carboniferous species described in the present paper, and in those described and figured by the officers of the United-States Survey, the denticles occupy almost every intermediate position between these two extremes, and hence the author was inclined to unite *Orthacanthus* with *Pleuracanthus*. *Compsacanthus*, Newb., is also probably nearly related to *Pleuracanthus*. The author described in some detail the characters of the genus *Pleuracanthus*, and discussed its scientific position, with regard to which he inclined to the adoption of Dr. Rudolph Kner's opinion that the Pleuracanths constitute a type of fish intermediate between the Elasmobranch and Teleostean fishes, but more nearly approaching the latter, probably through the Siluroids.

Ten species of the genus *Pleuracanthus*, modified as above, were described by the author from the Coal-measures, principally of Yorkshire. Eight of these were described as new.

2. "On the Schistose Volcanic Rocks occurring on the West of Dartmoor, with some Notes on the Structure of the Brent-Tor Volcano." By Frank Rutley, Esq., F.G.S.

Among the ashy beds of this district are certain amygdaloidal schistose rocks, which the author is of opinion are really lava-flows, which have probably been crushed or infiltrated, and have so assumed a foliated structure owing to pressure from superincumbent beds acting on rocks thus constituted. They are much altered, but were probably once basalts. The anthor considered it very probable that these schistose beds and Brent Tor, considered to be of Carboniferous age, are identical with beds near Tavistock and in the Saltash district, which are of Upper Devonian age.

In the concluding part of the paper the author described the beds of alternating ashes and lava, now much disturbed by faults, which constitute all that remains of the ancient Brent-Tor Volcano, and endeavoured, from the evidence which can be thus obtained, to give a probable reconstruction of the former cone.

3. "On Mammalian Remains and Tree-trunks in Quaternary Sands at Reading." By E. B. Poulton, Esq., F.G.S.

The author described in detail a pit opened on the south slope of the Thames Valley on the Redland Estate at Reading, about 36 feet above the river-level. The north face shows gravels and alluvia containing chalk-flints and fossils, fragments of Oolitic limestone and fossils, and scattered materials of the high-level gravels overlying reconstructed beds (sands and clays) composed chiefly of the *débris* of the Woolwich and Reading beds, and in part of the basement bed of the London Clay. The author noticed especially the traces of fluviatile action displayed in these reconstructed Tertiary materials, and the fossil-remains found in the sands and gravels, which included traces of *Elephas primigenius, Bos primigenius, Equus fossilis,* and ? *Rhinoceros tichorhinus*, besides numerous portions of trunks of trees, in some parts of which traces of coniferous structure had been recognized. The characters presented by this pit were of interest, as adding another to the scattered evidences of the existence in post-glacial time in the valley of the Thames of a larger river occupying that valley, and flowing at from 20 to 30 feet higher than the present river.

II.—February 4.—The President announced that a circular had been sent to the Society, stating that certain old students of Freiberg were endeavouring to collect the means for erecting a monument in Freiberg to the memory of the late Prof. Bernhard von Cotta, and, further, of establishing a Fund for the assistance of needy students at the Mining Academy of that place.

The following communication was read:—

"On the Oligocene Strata of the Hampshire Basin." By Prof. John W. Judd, F.R.S., Sec. G.S.

The study of the succession of strata in the fluvio-marine series of the Isle of Wight and the New Forest is attended with considerable difficulties, partly on account of the inconstant character of the beds composing estuarine formations, and partly because of the thick superficial deposits which everywhere cover them. By Webster a Lower Freshwater Series, a Middle Marine, and an Upper Freshwater Series were recognized; but Mr. Prestwich showed, in the year 1846, that at Hamstead Cliff we have both freshwater and marine strata lying above all these; and, in 1853, Edward Forbes proved that the marine and freshwater strata seen at Bembridge Ledge were not, as had previously been supposed, the equivalent of those of Headon Hill, but occupy a distinct and higher horizon. Hitherto, however (in spite of some suggestions to the contrary which were made by Dr. Wright and Prof. Hébert), the strata exposed at the base of Headon Hill have been believed to be a repetition, through an anticlinal fold, of those seen at Colwell and Totland Bays.

In the present memoir it is shown, both by stratigraphical and palæontological evidence, that the Colwell- and Totland-Bay beds are distinct from and overlie those at the base of Headon Hill. The distinctness and importance of the purely marine series exposed at Whitecliff Bay, Colwell Bay, and several localities in the New Forest is pointed out; and it is shown that, among the 200 forms of Mollusca which they contain, only one-fifth are found in the Barton Clay below. For this important division of the strata the name of the *Brockenhurst Series* is proposed.

In consequence of the detection of an error in the accepted order of succession of the strata, a rectification of the classification of the fluvio-marine series is rendered necessary, and it is proposed to divide them as follows:—

1. The Hempstead Series (marine and estuarine), 100 feet.
2. The Bembridge Group (estuarine), 300 feet.
3. The Brockenhurst Series (marine), 25 to 100 feet.
4. The Headon Group (estuarine), 400 feet.

By this new grouping the strata of the Hampshire Basin are brought into exact correlation with those of France, Belgium, North Germany, and Switzerland; and the whole series of fluvio-marine beds in the Isle of Wight, which are shown to have a thickness of between 800 and 900 feet, are proved to be the representatives of the Lower and Middle Oligocene of those countries. The use of the term Oligocene in this country is advocated on the ground that by its adoption only can we avoid the inconvenient course of dividing the fluvio-marine series between the Eocene and the Miocene.

CORRESPONDENCE.

PETROLOGICAL NOMENCLATURE.

Sir,—In a paper on the Rocks of Brazil Wood (Geol. Mag. 1879, Decade II. Vol. VI. p. 481), I described the so-called *peculiar gneiss*, and considering that it had been wrongly named, I called it a micaceous schist. As I strongly object to changes of names without sufficient reason, I wish to add a few words on the subject, more especially as it appears from a letter (see Geol. Mag. Jan. 1880, p. 47) that Prof. Bonney is not persuaded that I have improved matters by the change just mentioned. After carefully reviewing what I said on the subject, I venture to think that I rather understated my case, and that the objections to the old name are really fatal to its retention. The fact is, that the rock in question has neither the chemical composition, mineral constitution, internal structure, nor even the external appearance of gneiss—a rather formidable combination of objections. In the first place, a reference to Roth's tables of analyses will show that the amount of silica in micaceous gneiss is, on an average of sixty analyses, quite 70·00, whereas the quantity in the Charnwood rock is only 54·01. 2nd. There is a total absence of felspar from the mass of the rock, although there is a little in the narrow band at the actual junction, but even this may belong to the granite. There is also far less quartz than I have seen in any true gneiss—merely a few grains being scattered here and there through the mass. As regards structure, I said there was no foliation, but that the rock was rather fissile in one direction. I here used the term foliation in the sense attached to it by Darwin, and which I think it ought always to retain, namely, a separation into folia or layers of different mineral composition. It will of course be admitted that a rock may be more or less fissile, or schistose, without being either a slate, or a foliated schist; in fact, among the older rocks, and in some districts, such rocks are of common occurrence, whereas foliated rocks are comparatively rare. Now, as we have to deal with rocks having three well-marked varieties of texture, we ought to have a corresponding number of terms for their designation; and I do not see why rocks which exhibit such varieties should not be described as slates, schists, and foliated schists.

However this may be, the term schist certainly ought not to imply or include foliation (or arrangement of two or more minerals in separate layers), as there is no necessary connexion between the two ideas. No doubt a foliated rock will nearly always be a *schist*, as it will *split* readily, but there are plenty of schistose rocks which are not foliated.

Now the texture of the Brazil Wood rock is precisely of this character, and as two micas are its chief constituents, I ventured to call it a micaceous schist; but not mica-schist, and only provisionally, for, as stated in my paper, I regard it as one of a group of rocks which have not yet received distinctive names; they are rocks of great interest, and I hope to have something more to say about them on a future occasion. It appears to me, therefore, that a new name which is fairly descriptive of the rock must be preferable to an old one which is altogether inappropriate. S. ALLPORT.

BIRMINGHAM, *January 12th*, 1880.

MR. H. B. WOODWARD'S ADDRESS TO THE NORWICH GEOL. SOC.

SIR,—The legend to the woodcut given on p. 75 of the February Number of the GEOL. MAG. having been accidentally omitted, the following explanatory statement is necessary:—

The lowest bed touched in the Subwealden Boring is the Oxford Clay, the succeeding beds (above the dotted line) traced northwards are Corallian, Kimmeridge Clay, Portland Beds, Purbeck Beds, Hastings Beds, Weald Clay, Lower Greensand, Gault and Upper Greensand (together), Chalk. The last two divisions continue as far as the boring at Wells. The uppermost beds at London and Harwich are the Eocene; those at Diss and further north are chiefly glacial deposits. The lowest bed passed through in the boring at Wells is the Lower Greensand, beneath which the Kimmeridge Clay (?) is just reached. Below the dotted line (on the section) three divisions of Palæozoic rocks are shown—the uppermost, distinguished by thick black lines, represents the Carboniferous rocks; the middle "dotted" division represents Devonian rocks and Old Red Sandstone; and the lower "jointed" division represents the Silurian rocks.

The Vertical Scale was 2000 feet to one inch.

H. B. WOODWARD.

ECCENTRICITY AND GLACIAL EPOCHS.

SIR,—In Mr. Hill's paper on "Eccentricity and Glacial Epochs," the following paragraph occurs in reference to Dr. Croll's contention that the accumulation of masses of snow and ice during the winter would tend to lower the summer temperature: "The First alleged reason," Mr. Hill says, "is the cold produced by masses of ice and snow. If this means that the snow will not be melted easily, because it cools the air, there is self-contradiction. Snow can only cool the air by abstracting heat from it, and if snow takes up the heat, the heat is spent in melting it. As for what is said about cold rendering air diathermatous, so much the better for the melting. If the sun's rays can readily pass through the air, they will the more readily reach the snow which they have to melt. These paragraphs are not worthy of the book."

Has not Mr. Hill misapprehended Dr. Croll's argument?

It appears to me to be of this kind. Regarding climate as the average condition of the atmosphere in respect to heat, and considering the atmosphere as in the main warmed, not directly by the radiant heat of the sun, but by contact with the warmed surface of the earth, then if under any arrangement of circumstances a portion of the earth's surface can remain permanently at a low temperature, the air in contact with that portion of surface (*i.e.* the climate of the region) will also be permanently cold.

Now since the heat that goes to melt snow and ice disappears as sensible heat and produces no rise in temperature, we have a case in point—a permanently cold surface—in regions covered with snow and ice as long as any of the frozen water remains unmelted. The presence of accumulated masses of snow and ice in any region would therefore result in a far *colder climate* than might be expected, taking into consideration only the amount of heat received from the sun. For as long as the temperature of the air is 32° F. or lower, whatever aqueous vapour falls will fall as snow, not as rain; therefore, while snow and ice remain, accumulation will probably not cease, even during the summer. Moreover, although the aqueous vapour coming from warmer regions, on condensing and crystallizing into snow, gives out heat, will that heat avail to raise the general temperature of the air above freezing-point? Will not much of it be lost into stellar space?

To sum the matter up, it is clear that if by some natural process the heat received in polar regions could be transmuted into some other form of energy, while that received in equatorial regions produced the ordinary heating effects, very different climatic conditions would prevail, even if it were possible that the actual amount of heat received in the two regions were the same. In snow-covered countries the bulk of the sun's heat received goes in the work of melting snow and ice, and produces therefore no effect in ameliorating the climate.

R. D. Roberts.

Jan. 21st, 1880.

We regret to record the death of Professor Baron von Seebach, Director of the Geological Museum, Göttingen. He was not only eminent as a man of science, but endeared by ties of warm friendship to a large circle of friends, who will deeply deplore his loss.

Erratum.—In Mr. Clement Reid's paper, "The Glacial Deposits of Cromer," Geol. Mag. Feb. 1880, at p. 56, the bracket for 'Lower Glacial' should not include the 'Forest Bed.'

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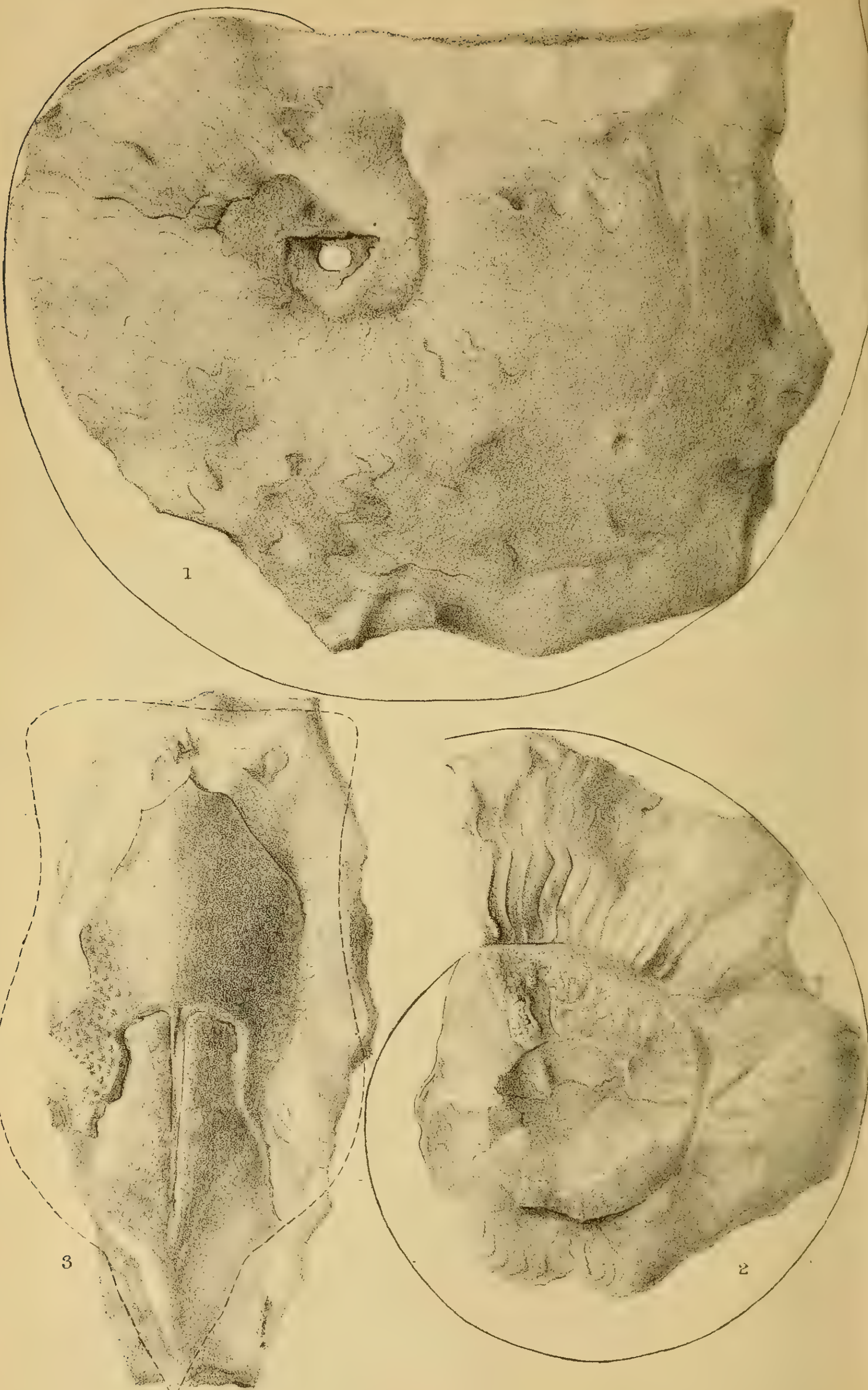

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U. Devonian Fossils, S. Devon.

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GEOLOGICAL MAGAZINE.
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No. IV.—APRIL, 1880.

ORIGINAL ARTICLES.

I.—Notice of the Occurrence of Upper Devonian Goniatite Limestone in Devonshire.[1]

By Prof. Dr. Ferdinand Roemer, For. M. Geol. Soc. Lond., of the University of Breslau.

(PLATE V.)

On a visit to Devonshire, in August, 1879, I was conducted by my friend, Mr. John Edward Lee, F.G.S., of Torquay, to a recently discovered locality at Lower Dunscombe, near Chudleigh, in which large *Goniatites* occur in considerable numbers in a bed of red limestone. On the slope of a chain of hills, not far from one of the farm-houses belonging to Lord Clifford, there is a ruined quarry, in which a vertical face of limestone is exposed.

The limestone at the top of the quarry is thinly-bedded, and is partly overlain by a red ferruginous limestone, which is separated from that beneath by a thin band of clay. This thinly-bedded layer is more or less filled with compressed *Goniatites;* the most frequently-occurring species being *G. intumescens*, Beyr., recognized as such by the form of its sutures. It attains sometimes to a diameter of nine inches.

These large specimens are always more or less compressed, and the body-chamber is also flattened. *G. multilobatus*, Beyr. (*G. sagittarius*, G. and F. Sandberger) is still more rare,—a smooth, discoidal, sharp-edged species, which is so named from the many serrated lobes of the closely approaching septa.[2]

Besides these *Goniatites*, a subcylindrical *Orthoceras* is especially abundant. It is perhaps identical with *O. acuarium*, Münster, which the brothers Sandberger have obtained at Oberscheld; but it is too imperfect to admit of identification with certainty. Numerous bivalves are met with, but they are also too imperfectly preserved to allow of safe determination, although one of them has the common form of *Myalina tenuistriata*, Sandb., from the Devonian Limestone of Oberscheld. More safely determinable is *Phacops cryptophthalmus*, Emmr., which is well known as a characteristic Upper Devonian Trilobite. I found a small, easily-recognizable head-shield of that species in the same rock-fragment with *G. intumescens*. Lastly, Mr.

[1] Translated from the Zeitschr. der Deutschen geolog. Gesellschaft, Jahrg. 1879.

[2] The brothers Sandberger have figured this species beautifully from perfect examples found at Oberscheld, and have fully described it under the name of *G. sagittarius*. Beyrich only knew incomplete specimens, but the characteristic form of the lobes and the general form of the shell were already correctly given by him, and therefore his name has the priority.

Lee has found an incomplete head-shield of a fish, which, from the sculpturing of the upper surface, is (certainly a [1]) *Coccosteus.* This specimen was exhibited at the Meeting of the British Association at Sheffield by Mr. Lee.[2]

Limestone beds rich in *Goniatites* such as are here described, have hitherto been unknown in England; their equivalents, however, exist on the Continent in the red Goniatite limestone of Oberscheld in Nassau, and of Adorf in Waldeck. Both at Chudleigh, and also at these German localities, *G. intumescens* is the most abundant species, whilst *G. multilobatus* is much more rare. *Phacops cryptophthalmus* is also not uncommon at Oberscheld. The character of the rock and the preservation of the fossils are also so similar that examples of *G. intumescens* from Chudleigh are hardly to be differentiated from those of Oberscheld or Adorf. Without doubt this thin-bedded limestone of Chudleigh, rich in *Goniatites,* belongs to the same geognostic horizon as the Upper Devonian Goniatite limestone in Nassau and in Waldeck. The conformity in the development of the Devonian series in England and Germany is thereby demonstrated. To Mr. J. E. Lee belongs the credit of being the first to draw attention to this occurrence. The same observer a few years since discovered, near Torquay, a bed corresponding to the Goniatite marl of Büdesheim in the Eifel.[3]

We have then in Devonshire, and also on the Rhine, the horizon of the primordial *Goniatites,* without *Clymenia* or the "*G. intumescens*" stage, developed in two forms.

As a whole, then, by a comparison of the Devonian slate series in Southern Devonshire and Cornwall with that of the Rhine, we have the following parallel table.

[1] In reference to Mr. Lee's specimen of dermal fish-plate, from the Upper Devonian of Lower Dunscombe, Mr. W. Davies, F.G.S., of the British Museum, observes, "There can be no doubt in pronouncing this fossil (Pl. V. Fig. 3) to be a median dorsal plate of *Coccosteus,* agreeing very well in general form with that plate in *C. decipiens,* Ag. (Table 8, Agassiz, 'Fishes of the Old Red Sandstone'), though probably nearer to *C. oblongus;* but from the imperfect state of its preservation it would be unwise to attempt its specific determination."

[2] In the black limestone, with *G. intumescens,* at Bicken, near Herborn, fish-remains have been found, which probably belong to *Coccosteus.* The limestone at Lower Dunscombe is probably equivalent to this.

[3] See "Notice of the Discovery of Upper Devonian Fossils in the Shales of Torbay," by J. E. Lee, Geol. Mag. 1877, Vol. IV. p. 100, Plate V. I have also visited this locality under the guidance of Mr. Lee, and can testify to the complete relationship of the small fossil fauna of the red slaty clays existing close to the sea-shore with those of Büdesheim. [No one, we are sure, would be more annoyed than Dr. Roemer at the slightest inaccuracy respecting the discoverer of any bed; and he will, we are sure, forgive us for stating that Dr. Harvey B. Holl, in his paper on Devonshire, etc. (Quarterly Journ. Geol. Soc. 1868, vol. xxiv. p. 413), actually gives a section of this very bed (without correlating it), which he calls the "Cephalopod bed"; but he places it unfortunately at Waddon Barton, where several geologists have searched for it in vain. Mr. Lee, we believe, in his notice at Sheffield (the published report of his paper was only in abstract), referred to Dr. Holl's section, and thought that Dr. Holl, had by some mischance confounded two localities within a mile of each other. As a fossil-bearing locality, Lower Dunscombe was hitherto comparatively unknown; although Mr. H. B. Woodward, in his recently published Geology of England and Wales, mentions the discovery of *Goniatites intumescens.*—Edit.]

COMPARISON OF THE DEVONIAN ROCKS IN SOUTH DEVON AND CORNWALL WITH THOSE OF THE RHINE.

		Devonshire and Cornwall.	Rhineland and Westphalia.
Upper Devonian.	Clymenia Stage.	5. Grey and greenish slate with nodular limestone near Petherwin, Cornwall, with *Clymenia*, *Goniatites* and *Spirifer Verneuili.*	Clymenia limestone in Nassau (Kirschhofen, near Weilburg) and Westphalia (Warstein).
	Intumescens Stage.	4. Red clay-slate of Saltern Cove near Torquay, Devonshire, with *Goniatites retrorsus*, *G. auris*, *Bactrites Schlotheimi*, *Cardiola retrostriata*, etc. Red ironstone, thin conformable limestone, and nodular limestone of Lower Dunscombe, by Chudleigh, with *Goniatites intumescens*, *G. multilobatus*, *Orthoceras*, etc., *Phacops cryptophthalmus*, *Coccosteus*, sp. indet.	Goniatite slate of Büdesheim. Red nodular limestone of Oberscheld in Nassau, and of Adorf in Waldeck.
Middle Devonian.		3. Compact grey limestone of Newton Bushel, Torquay, Plymouth, with *Stringocephalus Burtini*, *Uncites gryphus; Megalodon cucullatus;* numerous corals.	Paffrath limestone (*Stringocephalus* limestone) by Paffrath, Elberfeld Schwelm and in the Eifel.
		2. Grey or yellowish clay-slate of Ogwell House, Torquay, with *Calceola sandalina;* Brachiopoda; *Fenestella*, etc.	Eifel limestone.
Lower Devonian.		1. Clay-slate of Looe, Cornwall, with *Pteraspis*[1] sp., *Pleurodictyum problematicum*, *Orthis laticosta.* Clay-slate of Meadsfoot Sands, near Torquay, with *Homalonotus*, sp.	Coblentz Grauwacke ("Spirifer sandstone" of the brothers Sandberger.)

EXPLANATION OF PLATE V.

FIGS. 1 and 2.—*Goniatites multilobatus*, Beyr. (= *G. sagittarius*, Sandb.)
FIG. 3.—Median dorsal plate of *Coccosteus* (near to *C. oblongus*, Ag.).
All from the Upper Devonian Goniatite Limestone of Lower Dunscombe near Chudleigh, South Devonshire (all natural size).

II.—ON THE CROMER CLIFFS.

By Mr. O. FISHER, M.A., F.G.S.

I HAVE read with much interest Mr. Reid's paper on the Glacial Deposits of Cromer. It is a valuable contribution towards the elucidation of a difficult subject. I cannot, however, think that at present the mode of accumulation of glacial deposits is finally settled. The old people, among whom I count myself, used to consider these heterogeneous mixtures to have been dropped from floating-ice, or to have gone down, ice and all, to the bottom of the sea, when so much of the ice had been thawed that the mineral matter exceeded one-twentieth of the whole bulk.[2] Now, however, many of the younger geologists, and especially those connected with the Survey, attribute much more importance to the action of great glaciers or ice-sheets, enveloping not only whole countries, but also filling up and advancing over what are at present sea-beds.

[1] *Pt. cornubicus.*

[2] GEOL. MAG. Vol. V. 1868. p. 550, note.

I have thought that glacial geology in a mountainous country, like Scotland or Wales, is a different matter from the like subject treated in connexion with obviously marine beds, as many of the beds in Norfolk are proved to be by the fossils they contain. It is therefore extremely gratifying to study a paper by a writer who, like Mr. Clement Reid, has made the latter branch of glacial geology his special study. For one is assured that he is writing on what he has intimate acquaintance with. On that account he will be the better able to explain any difficulties which his paper suggests, and also to appreciate any clue, which another observer may have detected, but which has since probably been obliterated.

I am now alluding to certain cavities, which I saw, many years ago, in the eastern flank of the curious chalk bluff at Trimmingham. I mentioned these in the paper that I read before the British Association at Norwich, in 1868, to which Mr. Reid has so courteously referred. And I am very pleased that he thinks I struck the right key for explaining the formation of this bluff. I think these cavities ought to throw some light upon the mode of accumulation of the Boulder-clay which envelopes the bluff; for when I saw them, they had been apparently exposed to view by its removal. They must therefore have been formed and filled in the interval between the formation of the bluff and its envelopment in Boulder-clay. But there remains the difficulty, that the glacial deposits which rest on the *top* of the bluff were evidently lifted up along with it. I do not venture to explain the matter; but I wish to draw Mr. Reid's attention to it.

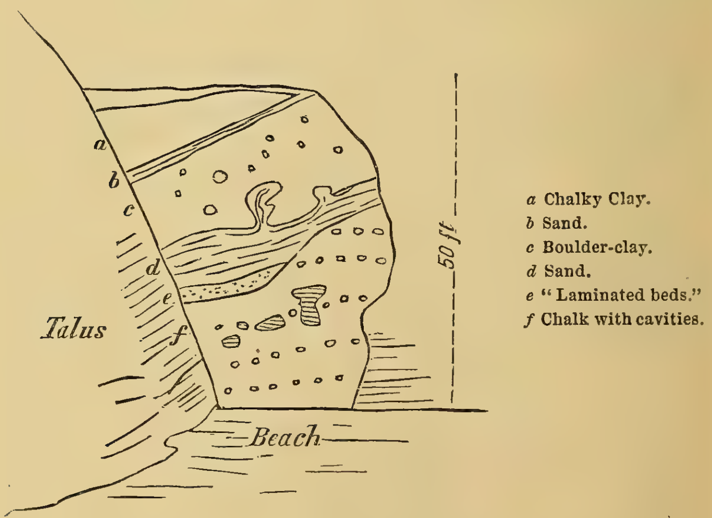
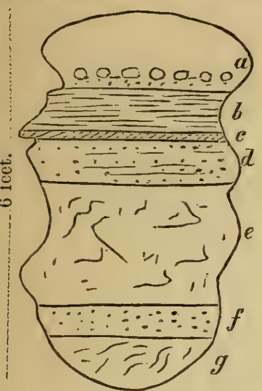


Fig. 1.—Eastern face of Trimmingham Chalk Bluff with caverns, as seen July 8, 1868.

The eastern side of the bluff is at right-angles to the line of coast. The sketches are copied from my note-book. I dug out all the material which the largest cavity contained, but found no organic remains in it. As far as I recollect, the back of it was soon reached, proving that it was not the section of a gallery. It was evident, from the horizontality of the contained deposits, that the cavity was filled, and from its shape almost certainly formed, after the chalk had acquired its present position. And, as stated, the cavity seemed to have been exposed to view by the removal of the Boulder-clay



a Sea sand with rolled and subangular pebbles, on this rest fragments of chalk and flint, and flints fallen from the roof. ... 4 in.
b Laminated calcareous sand with specks of carbonaceous matter. The material is apparently derived from partially dissolved chalk ... ... 10 in.
c Black carbonaceous layer ... ... 2½ in.
d Calcareous sand without carbonaceous matter... ... ... 1 ft.
e Disintegrated chalk.
f Fine sand.
g Disintegrated chalk.

Fig. 2.—Contents of the largest cavern observed in Fig. 1.

in which the bluff was originally enveloped. If any such cavities had at any former time existed on its northern face, the waste by the action of the sea must have long ago obliterated them.

On the iceberg theory these cavities are hard to account for. On the glacier theory I think still harder. I should like to hear whether any of them are still to be seen, and what conclusion can be drawn from them. I confess to having destroyed the evidence of the filling up of the one now described, and am all the more bound to put the facts on record.

May I now be permitted to offer a few remarks upon Mr. Reid's paper?

And first I would suggest that his Diagram Fig. 4, p. 64, supposed "to illustrate the mode of formation of the contortions," would be misleading to any one who has not visited the spot. The diagram would answer very well to represent a series of contorted beds near a mountain axis of elevation. But the contortions in the Cromer drift are more devoid of system. Fig. 2 gives a better idea of them, because it has been drawn from nature. So also, and for the same reason, does the diagram I gave (Vol. V. Geol. Mag. p. 550). But no diagram can give a generalized notion of the whole effect, because to do so it must assume the *modus operandi;* which is the very thing we do not know.

And here let me say that I do not think the alternative lies, as implied by Mr. Reid, between the "ploughing" action of icebergs and the assumed "pushing" action of a great glacier or ice-sheet. I submit that many, at least, of the appearances in the Cromer cliffs are better explained by the theory I suggested in my paper already referred to. I thought that the contortions, seen in the cliff, showed the intersection of its face with undulations *radiating* from centres, like those formed on still water when its surface is disturbed, rather than its intersection with *parallel* rolls like those shown in Mr. Reid's diagram. My theory was thus expressed (*op. cit.* p. 549): "If a mass of material is spread out *equably* over another, both being in a plastic state, the surface of their junction will be horizontal. But if a quantity of one such material be dropped *upon a limited space* of the other, it will sink down into it, and the depth to which it sinks into it will depend upon the quantity which falls. The material of the lower stratum, which is squeezed aside by the intrusion, will be driven into folds all around the area invaded by the foreign mass. This will, I believe, explain many of the anomalies of what has been called the contorted drift. Wherever considerable contortions occur, they will be found to be connected with the dropping of a mass of sand, gravel, or chalk, or of some matter differing from the stratified clay which is thrown into contortions by it. When the mass is very large, it sometimes has sunk down through, not only the upper, but also, the lower part of the Lower Boulder-clay" (1st Till); "and in one case I noticed that it had deranged the horizontality of the laminated" (Preglacial) "beds beneath." This case is illustrated by the diagram already referred to as well as by those given below. Suppose a boat load of sand and gravel dropped upon the muddy bottom of a pond: that would be an illustration of what I mean. My supposition would explain the upper part of the drift being sometimes less contorted than the lower (as marked by Mr. Reid), because nearly level sheets might be subsequently spread over sunken masses.

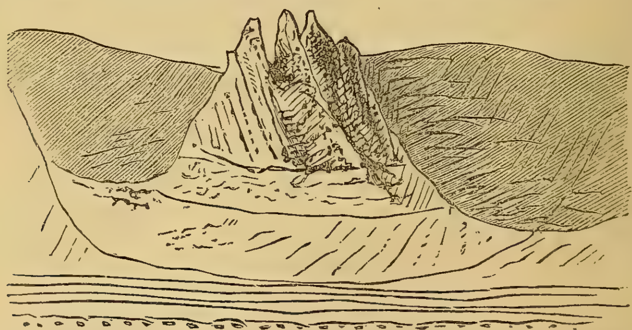


Fig. 3.—Aiguilles, derived from a mass of nearly vertical beds of shingle, denuded out of the face of the cliff of glacial sandy clay ("contorted drift") in which it was once enveloped; as seen from the beach beneath. Near Sherringham, May, 1864.

With regard to the "Chalky Boulder-clay," I confess that I supposed that the "Chalky Boulder-clay," or third division of

Messrs. Wood and Rome's series, did not occur in the Cromer cliffs. In fact, I thought that there was scarcely any of this deposit in Norfolk, except where it borders upon Suffolk. Perhaps I was wrong. But if Mr. Reid means by this term that same clay, which extends far inland, even to the west of this place, near Cambridge; then I think that his explanation of its origin ought to cover the whole case. Are we to understand that an ice-sheet, descending from the higher grounds of Lincolnshire, and from the chalk range

a Chalk with 'pan' of crag and large flints.
b Laminated sandy clay, probably of the age of the forest bed.
c "Laminated beds."
d Twisted and vertical beds of shingle, possibly deposited in a frozen state.
e Sandy glacial clay.
f Talus.

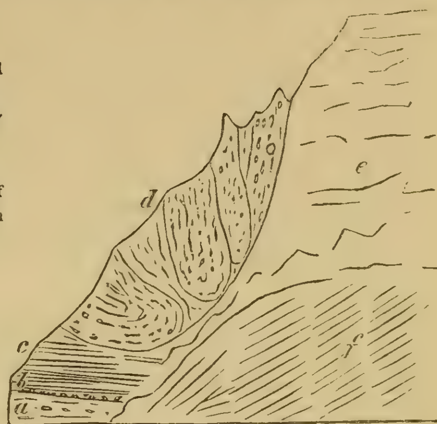


Fig. 4.—Side view of the same mass, represented in Fig. 3, as seen from the west, three years later, when it had been considerably reduced in volume, and the structure rendered more apparent.

generally, flowed towards where is now the German Ocean, and brought with it as a ground moraine this great mass of material; while another still mightier ice-sheet, coming from Scandinavia, met it, and prevailing against it along the coast of Norfolk, rode over the present coast-line, carrying beneath it masses of chalk derived from where is now the sea-bottom, and depositing them amidst the drift it was contorting: so that the chalky material of the Boulder-clay in the cliff has come from the east, while that of the inland mass has contemporaneously come from the west? Whither did these two great ice-flows send their mingled streams? Was there any water then in the German Ocean, or was it all ice? And lastly, is the "glacial submergence" theory abandoned? For it appears to me that land-ice near the sea-level and submergence are incompatible, and deepened seas and seas filled with ice equally so.

I ask all these questions in good faith. I possibly ought to know what the answer to them will be. But I do not; and some other of our craft may be as ignorant as myself, and be glad to read the replies. We none of us, I am sure, know all we could wish about the Glacial Period, its causes, and its effects; and discussion may be of service.

III.—Notes on the Vertebrata of the Pre-Glacial Forest Bed Series of the East of England.[1]

By E. T. Newton, F.G.S.,
of H. M. Geological Survey.

PART I.—CARNIVORA.

FOR the purposes of a memoir, about to be published by H.M. Geological Survey of England, on the Geology of parts of Norfolk, I have been for some time past engaged in a critical examination and revision of such lists of the so-called "Pre-Glacial Forest Bed" Vertebrata, as have appeared from time to time in various publications.[2] And it is intended to publish the results of this work in detail, when figures of the more important specimens will be given, together with particulars of the reasons for the alterations and additions which it is deemed necessary to make. It seemed desirable, however, as some time must elapse before the entire work can be accomplished, to publish, as occasion serves, short notes of some of the changes about to be made; and it is hoped that these notes will not be without interest to the readers of this Magazine.

The present communication will be limited to the consideration of the *Carnivora* which have been obtained from the "Forest Bed Series." The genera and species of this group, which have been recorded by writers as occurring in this series of deposits, are given in the following list, but it would only be tedious to enumerate here the sources from which the list has been compiled.

Carnivora which have been recorded as occurring in the "Forest Bed Series." (See also corrected list at conclusion of this communication.)

Canis lupus.	*Ursus spelæus.*
—— *vulpes*	—— *arvernensis.*
Hyæna spelæa.	—— *etruscus.*
Machairodus latidens.	—— *arctos.*
Lutra.	—— *priscus* (Falconer MS.).
Trichechus rosmarus.	

Canis lupus and *C. vulpes* appear each to be represented by one specimen only, the former by a portion of a humerus, and the latter by a part of a lower jaw. There is some doubt as to both these species. The portion of humerus, now in the Museum of Practical Geology, forms part of the King Collection of "Forest Bed" mammals, but the locality from which it was obtained is not known, and consequently its horizon is uncertain. It is quite possible that this specimen may have belonged to a Wolf; but it might equally well be referred to Dog. The piece of a lower jaw, in the Green Collection, at the British Museum, No. 18,236,

[1] Published by permission of the Director-General.

[2] As it is most desirable in such work as this that all available material should be examined, the writer would esteem it a favour if any one, possessing specimens of Vertebrata from the "Forest Bed," or knowing of the existence of such specimens in any private collections, would communicate with him at the Museum of Practical Geology, Jermyn Street, S.W.

which seems to be the only "Forest Bed" specimen which could be referred to *C. vulpes*, might possibly have belonged to a small Dog. However, it seemed better not to remove these names from the list, but to indicate their doubtful character by a note of interrogation placed after the species.

Hyæna spelæa is mentioned by Mr. A. Bell (Geol. Assoc. 1871) as occurring in the "Forest Bed"; but as I cannot get the slightest clue to any specimen from this horizon which might be referred to this genus, it becomes necessary to omit the name from the list.

Machairodus sp.—There is no doubt that the tooth from the "Forest Bed" described by Prof. Lankester (see Geol. Mag. 1869, Vol. VI. p. 440, Pl. XVI.) was correctly referred by him to the genus *Machairodus;* but I cannot quite agree with those authors who have thought fit to place it in their lists as *M. latidens*. This tooth when perfect must have been much more elongated than the specimen from "Kent's Hole," figured by Prof. Owen (Brit. Foss. Mamm. p. 180, fig. 69); and although it approaches more nearly in this respect to some other specimens from the same place, it seems to me to resemble more closely the continental species *M. cultridens*. I hesitate, however, on such slender evidence, to refer the specimen to either species.

Ursus.—No less than four species of Bears have been recorded as occurring in the "Forest Bed," and, if we include Dr. Falconer's MS. of *Ursus priscus*, there would be five species. This multiplicity of names has arisen, not from the number of different species which have been found, but from the fact that authors have not been agreed as to the species to which the specimens should be referred; and others again, in compiling lists, have accepted all the names without eliminating those which were merely synonyms. This confusion has partly arisen from the fact that, with one or two notable exceptions, the lists of "Forest Bed" mammals have been published without any clue to the specimens upon which the specific determinations rested. After a careful examination of all the Bear-remains from the "Forest Bed," of the existence of which I have been able to obtain any information, I am led to the conclusion that they indicate only two species: the majority and the best-preserved among them being clearly referable to *Ursus spelæus*; while one maxilla, on account of the size of its teeth, evidently belonged to a second species, and is referred with some doubt to *U. ferox-fossilis*, Busk (=*fossilis*, Goldf.). I have hitherto been unable to find in any collection a specimen which could be referred to *Ursus arvernensis*. This will be as much a matter of surprise to other palæontologists as it has been to myself. Prof. Busk has most kindly examined all the specimens with me (that is, all of which I have any knowledge), and permits me to say, that he agrees with the above determinations, and that neither of these specimens can be referred to *U. arvernensis*. However, Prof. Busk was under the impression that the latter species had been obtained from the "Forest Bed," and that there was a specimen in the Norwich Museum. Mr. J. Gunn, F.G.S., of Norwich, assures me that he has no knowledge of any such specimen, and he further says, that the lower jaw in the Norwich Museum (Miss Gurney's Collection) was referred by M. Lartet to *U. arvernensis.* Prof. Busk agrees with me that this specimen can only be referred to *U. spelæus.* This determination of M. Lartet's may possibly have caused the name to be put in the lists; but as no description of a specimen of *Ursus arvernensis* from the "Forest Bed" appears ever to have been published, it becomes necessary to expunge the name from our lists, until more definite evidence can be obtained.

Trichechus rosmarus.—A portion of a tusk, from the "Forest Bed" near Cromer, closely resembling that of the recent Walrus, has caused this name to be inserted in the lists. It appears to have been more rapidly tapering and more compressed than is the case in *Trichechus rosmarus,* and more closely resembles some of the Red Crag forms, called by Prof. Lankester *Trichechodon Huxleyi.* I am unable to agree with Prof. van Beneden, that the Red Crag tusks should be referred to the genus *Alachtherium,* and seeing no real difference between the "Forest Bed" tusk and those from the Red Crag, I refer it to the same species, *Trichechodon Huxleyi.*

Certain forms have now to be mentioned which have not hitherto been recorded as occurring in the "Forest Bed."

There is in the King Collection, at the Museum of Practical Geology, the lower end of a *fibula* which has been regarded as ursine, but upon close comparison it is found to agree much more closely, both in size and form, with the same bone in the larger *Felidæ,* than it does with any bear's fibula with which I have been able to compare it. It is quite possible that this bone may have belonged to *Machairodus;* but, be that as it may, it must be taken as further evidence of the occurrence of the family of the *Felidæ* in the "Forest Bed."

Prof. Flower has recently had sent to him from the same horizon, near Pakefield, a portion of a humerus, which, on account of its having possessed a supra-condylar foramen, and having the upper part much compressed laterally, and because of its resemblance to the humeri of some of the larger *Felidæ,* he believes to have belonged to a representative of that family. The specimen is of especial interest on account of its having been found *in sitû,* and it is hoped that Prof. Flower will shortly publish a description of it. In the meanwhile it may be regarded as most important additional evidence of the occurrence of the *Felidæ* in the "Forest Bed."

Quite recently, my colleague, Mr. Clement Reid, has obtained from the lacustrine deposit at West Runton a portion of a lower jaw of a small carnivore, with the large carnassial tooth in place. This specimen agrees so precisely in size and form with the same parts in the recent *Martes sylvatica,* Nilss. (= *Mustela Martes,* vide Alston, Proc. Zool. Soc. 1879, p. 468), that there can be no doubt as to their specific identity. This is the specimen which was by mistake called *Lutra* in Miller's and Skertchley's "Fenland," p. 505.

The same gentleman has likewise obtained from the so-called "Weybourn Beds" at Runton a small bone which I believed to be the radius of a small Seal. I was enabled to compare this specimen with the skeletons of some young Seals in the Royal College of Surgeons, through the kindness of Prof. Flower, who, I believe, agrees with me, that although it would be very hazardous to give any specific name to this specimen, yet there can be no question as to its belonging to the genus *Phoca*. Mr. A. Savin, of Cromer, possesses a small canine (?) tooth from the "Black Bed" at West Runton, which there is little doubt belongs to the same genus.

Since the above has been in type, Mr. R. Fitch, of Norwich, has kindly forwarded to me a portion of a lower jaw with teeth, lately obtained from the "Forest Bed" of Mundesley, which, so far as preserved, agrees precisely in form with the same parts in the Glutton. I am enabled therefore before going to press to insert *Gulo luscus*, as a "Forest Bed" species.

If the above emendations and additions prove to be correct, then the Carnivora at present known from the Pre-Glacial "Forest Bed Series" of the East of England are as follows (those marked with an asterisk are new to the "Forest Bed"):—

Canis lupus ? Linn.	**Gulo luscus*, Linn.
—— *vulpes* ? Linn.	*Ursus spelæus*, Blum.
Machairodus sp.	—— *ferox-fossilis* ? Busk.
Felidæ (? genus).	*Trichechodon Huxleyi*, Lank.
**Martes sylvatica*, Nilss.	**Phoca*, sp.

IV.—On the Pre-Cambrian Rocks of West and Central Ross-shire.

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

With Petrological Notes.

By T. Davies, F.G.S., of the British Museum.

Part II.

Loch Maree and Glen Laggan (or Logan).

LOCH Maree runs roughly parallel with the strike of the beds of the Pre-Cambrian rocks, consequently there is no great thickness of these rocks exposed along its shores, and we do not find the same variability in their character, as in the area previously described. Along the S.W. shores the gneisses described in Notes 4 and 5 are most frequently met with, especially towards the western end; but about the Loch Maree Hotel, and eastward of this point, the gneisses described in Notes 7 and 8 are the prevailing types.

[Note 7.—Macroscopically appears to consist of a fine-grained admixture of felspar and quartz in bands with mica. The foliation in this case is not so distinctly dependent upon the mica, but is largely contributed to by the quartzo-felspathic bands. A thin section shows that the quartz in this rock is eminently crystalline, and forms continuous bands, which inclose the individual crystals or groups of felspar. It is exceedingly free from the microscopic cavities. It appears frequently as a rounded crystal inclusion in the felspar crystals. The felspar is reddish-grey in colour, and is much altered; but from its peculiar striation and traces of reticulation, I am disposed to refer it to the species microcline. It occurs as single crystals, or as a line of contiguous crystals having an irregular but perceptible parallelism with the quartz. The mica is much altered, but from its marked dichroism it would appear to be biotite; a little monochromatic mica (muscovite?) is also present. The mica is distributed throughout, and only here and there does it appear grouped into thin bands. Sphene is present here also, with a little garnet and some magnetite.—T.D.]

[NOTE 8.—A close medium-grained rock with much red felspar, dark-coloured mica, and a soft yellowish-green substance resembling some varieties of ripidolite; but little quartz visible. When examined in thin section, a greyish-red felspar, much decomposed, is found to constitute the larger part of the rock. It bears the aspect of orthoclase. Quartz is in exceedingly small amount in this rock, and appears only as an occasional occupant of interstices between the felspar crystals, or inclosed in them. The mica, which is considerably altered, is almost opaque, exhibiting only in places a distinct dichroism. A serpentinous mineral of a clear yellowish-green colour, lying like the mica in distinct bands, is abundant. From its crystal contours, and the manner in which it is associated with the felspar, it is probably a pseudomorph after hornblende, though no trace of this mineral is now discernible. It is but faintly doubly refracting, and exhibits with polarized light a mosaic-coloured ground. Much of a black opaque mineral in minute grains, probably magnetite, is distributed through and around this mineral. Garnet in minute crystals is frequent. Evidently a highly felspathic gneiss. —T.D.]

Similar gneisses to those above described are found also along the N.E. shores, especially towards the eastern end. For some distance, about the middle, a thick band of limestone is traceable, and at Ben-Lair hornblende strata prevail. The following description is given by Murchison and Geikie[1] of the rocks along this shore:—"On the right bank of Loch Maree this gneiss (older) contains both limestone and ironstone, which occur in bands regularly interstratified, and which have the normal strike of these ancient beds, as in the outer Hebrides. This strike from N.W. to S.E. is therefore parallel to the great depression occupied by the water of Loch Maree. In no portion of the North-Western Highlands is there a track which more completely exhibits the entire independence of this Laurentian gneiss of all those overlying deposits, also termed gneiss, with which Prof. Nicol has recently sought to identify it. . . . We therefore call special attention not only to the N.W. strike of the beds of this fundamental rock, as contrasted with the north-easterly strike of the eastern rocks, but also to the marked distinctions in lithological composition between it and any of the overlying masses." Again,[2] "In short, between Loch Maree and the sea-board at Gaerloch, wherever the fundamental gneiss is uncovered in low masses beneath the superjacent masses of Cambrian sandstone, the persistence of the

[1] Quart. Journ. Geol. Soc. vol. xvii. p. 176. [2] *Ibid.* p. 178.

N.W. strike is clearly maintained." The persistency of a N.W. strike in the Pre-Cambrian rocks at Gaerloch, Torridon and Loch Maree is undoubtedly a fact of great importance, and must not be lost sight of in any examination carried into the adjoining areas ; and if such a strike is found in any of these in association with the only other evidence referred to in the above remarks, viz. an identity in lithological composition, the evidence of correlation in the rocks belonging to those areas must be considered conclusive as far as these authors are concerned. Indeed, most geologists who have had much experience amongst the older rocks, and who have been able to realize thereby the prevailing influences, physical and chemical, to which they have been subjected, cannot fail to arrive at some such conclusion. The Pre-Cambrian rocks along both sides towards the eastern end of Loch Maree, as at Gaerloch and Torridon, are covered by Cambrian conglomerates (or breccias) and sandstones, derived as there from the immediately underlying rocks. They rest horizontally, or with a very slight inclination to the S.E., on the upturned edges of the older rocks, and fill up the unevennesses of the surface frequently recognizable on the old Pre-Cambrian floor. This floor it is clear remains much as it was when the overlying rocks were deposited upon it, and its subsequent elevation must have been produced without materially altering the configuration of its surface. It has of course been fractured at many points, and consequently dragged down with it at these places the overlying rocks. In its then crystalline (metamorphosed) state it could not bend nor yield in any other way than by fracturing, and it behoves us not to forget this in our inquiries, for it offers the clue by which we may judge as to what physical changes these rocks could possibly have been subjected to since.[1] The floor and the overlying rocks are dropped to a lower horizon on the south side of the lake than on the north, by the fault which runs through and parallel with the lake. This fault, however, is a mere downthrow to the S.W., and has not in any way interfered with the strike either of the lower or with that of the overlying beds. Indeed, all their distinctive characters, and their relations to one another, are exactly the same on both sides of the fault. I call especial attention to this fact (it is referred to also by Murchison and Geikie)[2]; for the interpretation here of the effect produced by this fault does not commend itself to some when applied to one part (Glen Docherty) along its course, where the results and the appearances generally seem to be identical with those observed here and throughout at many other points.

There are some apparently who would rather believe in the possibility of twisting a large portion of the old metamorphosed floor, with its superincumbent weight, at right-angles for several miles to that from which it has been detached, without greatly

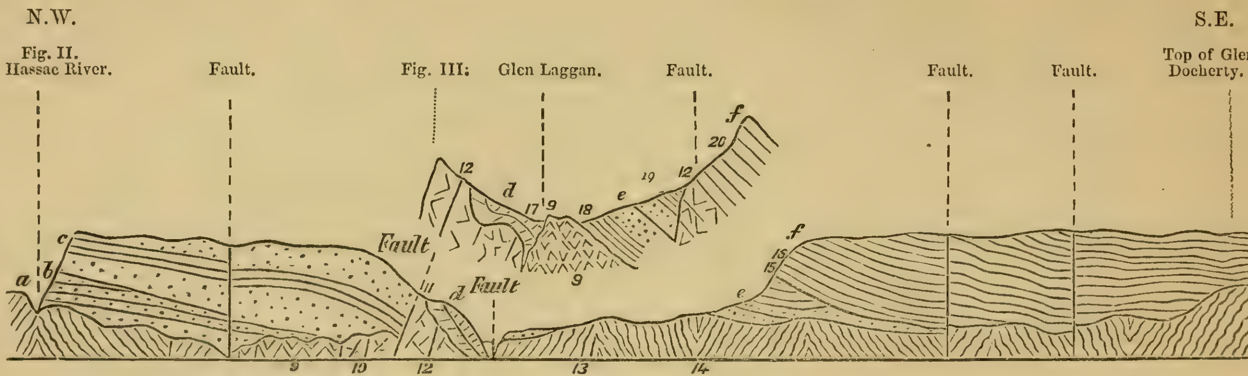
[1] Rather too much of the floor is left uncovered in the map to the north of Ben Larig. The exposures are chiefly here along lines of valleys and the borders of lakes.

[2] Quart. Journ. Geol. Soc. vol. xvii. p. 190.

disturbing the strike of the overlying rocks, than accept so simple an interpretation. These are, however, matched in their dream of possibilities by those who have suggested that the overlying rocks have, by some process of twisting, or sliding, been made to reappear below in the character of the old rocks, with a strike there at right-angles to themselves, and a nearly vertical dip, and this for a distance of several miles. Possibly the very palpable difference between a conglomerate and the underlying rocks may have prevented any such idea being entertained in the more immediate neighbourhood of Loch Maree. Otherwise, had the overlying rocks been made up of finer materials, and yet derived from the same sources—detrital from gneisses, granitic and felspathic rocks, and hornblende and mica-schists—the case might have been different, and by some powerful stretch of the imagination such a result might even here have been thought possible. That some of the overlying rocks do occasionally simulate those from which they have been derived is well known, and the following remarks on the lower beds of the conglomerate series by Prof. Nicol are instructive on this point:[1] "Fragments of gneiss and granite are baked up in the mud of decomposed felspars, mica and peroxide of iron. The deeper beds are frequently purplish brown; the higher, darker or bright red. The lower portion too near the sources of heat are hardened and compacted almost like the gneiss or granite out of which they were made. Sometimes they have even been mistaken for gneiss." Detached crystals and fragments of felspar, hornblende, garnet, etc., are also very commonly present in the finer sediments, and the admixture of these is sometimes so complete, that at first sight one may be led to think that the rock was truly crystalline. This, however, can generally only occur in small specimens, for, when a mass of any size is examined, larger fragments with irregular outlines are visible, and the brecciated character of the whole is easily made out. This curious crystalline appearance sometimes assumed by the Cambrian rocks is due in a great measure to the very slight amount of attrition to which the materials composing them have been subjected, and to their having been derived primarily from crystalline rocks. Bits of vein quartz and granite, in addition to fragments of the schists, or of some of their crystalline constituents, compose nearly the whole of these Cambrian conglomerates and sandstones. Scarcely any decomposition comparatively of the various minerals had by this time taken place, and organic life had added but little to the sediments; hence the ordinary results of decomposition, the muddy and other deposits found in more recent strata, are here nearly altogether absent. These Lower Cambrian rocks are followed, on both shores of the lake, by quartzites, usually made up of very minute grains. These rest unconformably upon the former, and evidently therefore belong geologically to a newer formation; whether of Upper Cambrian or of early Silurian date is at present doubtful. On the north-east shore, nearly at the eastern end of the lake (Section II.), a fault is seen

[1] The Geology and Scenery of the North of Scotland, 1866, p. 28.

Figs. II. & III. Sections across Glen Laggan (Glen Logan in Map).



a Pre-Cambrian. *c* Quartz rocks and flaggy beds. *d* Limestone, *e* Blue flags and Sandstones, *f* Quartzose and Micaceous flaggy beds.
b Lower Cambrian.

Silurian.

The numbers indicate the position of the rocks described in the petrological notes.

cutting across, though yet apparently in the line of strike of the last-mentioned rocks, dropping them to a lower horizon towards the S.E. The floor of Pre-Cambrian rocks, observed to be gradually sloping from the west towards this point, is further dropped also by this fault, and its continuity broken by an intrusion of the igneous rock described in Note 9.

[Note 9.—A macroscopic examination exhibits a compact felsitic base, grey to pinkish grey, in which is thickly distributed a hornblende-like mineral in crystalline spots and patches. When a thin section is examined, it is found to consist very largely of a dark-green mineral, which is rendered very obscure by the amount of alteration which the whole rock has undergone. It is very slightly dichroic. The habit, however, of a considerable part of it is so like that of hypersthene that I am disposed to refer it to that species for the present. The felspar is entirely decomposed, small spaces and interstices being occupied by a little calcite and secondary quartz. I regard this rock as a much altered hypersthenite. It is undoubtedly intrusive, and has nothing in common with the hornblende gneisses. —T.D.]

In my former paper this mass was described as syenite. Mr. Davies now calls it a quartz diorite. Whether this mass directly beyond the fault extends continuously under the sedimentary rocks to reach a similar mass met with in the centre of Glen Laggan, I am unable to say. In any case they are sufficiently identical in character to be so associated. The largest exposure in Glen Laggan, from where the specimen actually described was collected, is seen on the sides of the river about a mile and half from the entrance to the Glen (Section III.). In its immediate neighbourhood the rocks are twisted and crushed, and also altered considerably. In the line of Section II. (which is taken along the Kenloch Ewe heights, and across the entrance of Glen Laggan), in the cliff immediately opposite Kenloch Ewe, a mass of rock is seen of a granitic type, but whether intrusive into the newer rocks like the quartz diorite is at present doubtful. It is described by Mr. Davies in his Note 10.

[Note 10.—This is a coarse granitic rock in contact with a vein of a hard, compact, pale yellowish-green substance. Microscopically we find coarsely crystalline orthoclase with plagioclase in nearly equal proportions, and quartz, the whole being pervaded with a microscopic dust which is more conspicuous in the felspars. No mica is visible. It differs from the gneisses generally in the more intimate crystallization of its minerals. The vein substance varies from crypto- to micro-crystalline, is doubly refracting, and, judging from its resemblance and the similarity in its mode of occurrence to that of the island of Iona, which has been shown by analysis to be a lime epidote, is to be referred to that species.[1] It contains much angular quartz, probably derived from the granitic rock, and is in places much crushed, so as to resemble a breccia. Smaller veins and patches of the same pervade the mass.—T.D.]

[1] Mineralogical Notices by Prof. N. S. Maskelyne and Dr. W. Flight, Journal of the Chemical Society, Jan. 1871.

On reaching Glen Laggan at a high level, on the west side, another exposure of a somewhat similar rock is found. Much of this, however, puts on the aspect of a serpentinous schist, but the main mass still has a highly granitic appearance. It reaches up to a height of several hundred feet above the level of the river at this point, and may also be traced continuously for several miles in the face of the hill along this side, striking apparently in a N.E. direction. It afterwards descends into the low ground, towards the upper end of the Glen. I walked along the ridge for several miles, and noticed its connexion with the associated rocks carefully. Where it is first met with, it looks as if it had been sharply cut across by a fault, and there is an indentation in the ground such as would lead one to suspect such an occurrence. It seems here to underlie the Limestone Series, and to be backed by the quartzites and the flaggy fucoidal beds. Whether this portion at the higher level is intimately connected with the mass described in Note 10, and with another which runs up at a low level in Glen Laggan, and exposed in the river at the entrance, cannot be accurately determined; but I believe all evidence points to this, and I have so indicated the connexion in the sections (in the present as in my former paper). The microscopical examinations, determined by Mr. Davies, from a series collected at all points, tend to the same conclusions. These results are described in Notes 11 and 12.

[Note 11.—A large grained crystalline association of quartz and red orthoclase, the relations of which are much like those of a granite, notwithstanding the apparent parallelism of the quartz groups. It is permeated by innumerable thin veins of a serpentinous substance, which varies much in translucency, and only occasionally shows traces of a crystalline condition. The rock weathers to a soft earthy substance resembling a kaolin, to some depth.—T.D.]

[Note 12.—Resembles a coarse-grained felspathic granite. The microscope shows a large grained crystalline association of quartz and a reddish orthoclase, with some microcline. The quartz is in more or less continuous bands, but appears to be frequently broken up and disturbed locally. The orthoclase is cloudy through decomposition. Much limonite as pseudmorphs after small crystals of iron pyrites is distributed.

A. Another specimen of the same rock mass shows more decided granitic characters. The felspar and quartz are more even in size, and the latter is not so marked in its parallelism. A soft greenish micaceous mineral is evenly distributed through it, and altogether this rock is macroscopically much like a granite.

B. Another variety of this rock is very coarsely crystalline, some of the felspar being very distinctly crystallized rather than crystalline. The quartz is bluish and somewhat milky, and resembles the variety known as fatty quartz. The mica here too, though apparently chloritic, shares in the increase in the size of the constituents, and though sparse is generally distributed.

C. Resembles *A.* in the relative size of the constituents, but contains much plagioclase. Nests of the green chloritic mica constituent here and there are suggestive of bands, but these are not frequent nor continuous; and these are the only indications which are here present as to a possible tendency to a gneissic structure.

The micaceous constituent in these rocks does not resemble in any way the muscovite and biotite of the undoubted gneisses, nor, with the exception of *A.*, does it occur similarly disposed. It is greenish, soft, and talc-like, and is probably hydrated and bears a considerable resemblance to ripidolite.—T.D.]

Two special types may be described therefore of these igneous rocks as warranted by Mr. Davies's careful notes, viz. granitic and dioritic (called granite and syenite in my former paper), and it seems to me that the varieties further recognized owe their peculiarities to the changes these have undergone in their passage through other rocks. They have frequently assimilated portions of rocks as they passed through them, and locally are considerably changed in appearance and partially in composition in consequence.

It is clear from the following remarks by Murchison and Geikie[1] that this changed appearance as they penetrated the various strata was also frequently recognized by them:—"In Glen Cruchalie (Glen Laggan) the most marked rock is one similar to that which was described as overlying the limestone at Loch-na-Fad, and underlying the quartz-rock at the mouth of the Hassac and along the higher part of the valley of Loch Maree. It is difficult to give this rock any one specific name, for like that in Sutherland, which we formerly described, it varies greatly in mineral composition, even within a few yards. Near the limestone it is a serpentine, the green mineral then thins away, and quartz and felspar take its place, while to these is occasionally added hornblende. The proportions of the ingredients also vary to a large extent. This rock, by whatever name we designate it, occupies a large part of Glen Cruchalie. Sometimes it lies only along the bottom of the glen; then it rises high on the one side and soon ascends among the slopes on the other. In some places it occupies indifferently the place of the limestone, in other parts that of the quartz-rock or the upper flaggy series, or it invades the three zones at once."

Prof. Nicol describes the intrusions near the head of Loch Maree and at Glen Laggan as follows:[2]—"A great mass of igneous rock, a fine-grained syenite, or rather diorite, forms the base of the hill (head of Loch Maree), covered by broken masses of quartzite and limestone. In the valley of the Laggan the limestone has been quarried in several places, dipping to E. 20° S., but much altered by the diorite, which forms a wide mass, running for several miles along the valley." The above remarks might lead one to think there was but one recognized type amongst these intrusions, and that the differences recognizable were due everywhere to accidental circumstances. I noticed, however, at once that we had here to deal with at least two types of intrusive rocks, probably entirely independent of one another, and of different age;

[1] Quart. Journ. Geol. Soc. vol. xvii. pp. 190 and 192.
[2] Quart. Journ. Geol. Soc. vol. xvii. p. 103.

and this seems now fully borne out by microscopical examination. The diorite undoubtedly alters the rocks in contact with it, and must therefore have been intruded after the Cambrian and Silurian sediments had been deposited. Contact alteration is less evident, if at all present, near the granitic mass; and it is not improbable that this was intruded like most of the granite veins into the Pre-Cambrian rocks before any of the newer deposits were formed. I am the more inclined to think this since a similar rock is found along the west coast near Gaerloch, intruded only into the Pre-Cambrian rocks, and at Loch Torridon fragments are found in the Cambrian conglomerates, which to all appearances might have been derived from such a mass as we have here. That it does not properly, however, belong to the true Pre-Cambrian gneiss series,[1] is evident from the direction in which it runs, here, and wherever examined further north directly across the strike of the old rocks. The normal strike remaining undisturbed in the gneiss rocks, which extend along and frequently in contact with both borders of the mass. For example, the strike in the Pre-Cambrian rocks is perfectly clear even after passing the Hassac Valley; and it is found equally well marked directly beyond the Laggan River, and in the undulating ground between that and the Glen Docherty heights. Now no series of faults would be likely to produce changes, so identical in character as these are found to be, continuously along this line: nor indeed does it seem at all probable that the strike would change so suddenly, be retained afterwards over so exceedingly narrow an area only, and then return equally suddenly to the normal direction. That the normal strike occurs everywhere in the old floor, where exposed on both sides of the mass, is undoubted, and the conditions observed at the entrance to the glen are seen equally clearly at the upper end—several miles from this point—the granitic mass intervening there as at the entrance to sever the connexion between the floor on either side.

Looking at all the evidence, in the three sections, which I made across Glen Laggan, I am inclined to think that this granite mass belongs to a Pre-Cambrian period, but that it is withal of intrusive origin. If this is the case an easy explanation may be given of the changes noticed in the section opposite Kenloch Ewe. The quartzites lie nearly horizontally where they first touch the granitic mass. A sudden bend then takes place as if they were dropped by a fault, and a nearly vertical face of the granitic mass is presented towards the quartzites. This would, therefore, indicate a faulted junction rather than an intrusion into the newer rocks. Another fault is met with in a line with the river, and beyond this the old floor is again reached. Here it maintains the relationship with the newer rocks, which was noticed before the broken ground opposite Kenloch Ewe

[1] Prof. Bonney, in some notes which he has just published (Quart. Journ. Geol. Soc. vol. xxvi. p. 95) says, "that all the so-called syenite (except some intrusive dykes) is simply a rather granitoid variety of the Hebridean gneiss." In this he includes the granitic rock just mentioned, but the evidence which I have brought forward seems to show that this is almost impossible, even if the petrological evidence strongly favoured (which it really does not) such a view.

was reached, being covered by Cambrian sandstone with the usual S.E. dip, whilst retaining in its own beds a strike at right angles to these, with high contorted dips.

As a probable explanation of the frequent occurrence of igneous rocks along this line from N.E. to S.W. may be mentioned, the depression which affected this line during and probably even before the earlier Palæozoic epochs. That the Palæozoic contractions were accompanied with elevations and depressions along lines more or less from N.E. to S.W. is generally granted for at least the British areas. Such a line extending from here through the length of Ross and Sutherland is indicated by the presence now of the newer deposits in the hollows so formed, and the crush seems to have been depressed to a greater depth and have suffered more from the pressure here than at any other, except in the parallel line along the channel separating the Hebrides from the main land.

This depression, as usual, was accompanied with many fractures of the crust, generally parallel with it, and these offered numerous channels and lines of weak resistance for igneous intrusions. These faults from N.E. to S.W., combined with those at right angles to them, comprise the main systems recognizable in these areas, and have contributed mainly in producing the physical features. Most of the Lochs and Lakes run in a direction from N.W. to S.E., or in lines of fractures along the strike of the old rocks. The wider and more regular depressions are, on the other hand, in lines more or less across the strike of the Pre-Cambrian rocks. Various local shiftings have taken place here and there also, but the general result is the same throughout, and is usually easily recognizable.

The more visible effect of all this upon the newer rocks has been to tilt them up and to crush them; but in addition, on careful examination, a further change is recognizable. The rocks in proximity to these intrusions are more or less altered (or metamorphosed) from the combined influence of contact with igneous rocks and the evolution at the time of heated vapours. It has been generally supposed that the overlying deposits have been less altered along this line than the still newer rocks further east, and at a distance from these intrusions, and various theories have been propounded to explain this seeming anomaly. Some supposing that at these places there are invisible igneous foci; others that some process of selective metamorphism has taken place. Curiously the advocates of these views seem quite to have forgotten that wherever great igneous masses are seen, no such changes are observed to have taken place in the neighbouring rocks for any considerable distance from the mass; selective metamorphism also should not affect all the rocks in an extensive area alike, and be entirely wanting in rocks presumably of like nature, made up of identically the same materials, derived from exactly similar sources, in neighbouring areas, which to all appearances have been subjected to the same influences. The evidence, as far as I am able to read it, goes to show that the most highly altered of the newer deposits are found along this line of depression usually in contact with intrusive rocks, or near fractures through which heated waters and vapours could have escaped. The rocks east of this line, supposed to be newer than any found here, but to be far more highly metamorphosed, are in my opinion much older than any of these, and to be of Pre-Cambrian age, as I shall endeavour to explain more fully further on.

The prolonged movements which affected the British areas during, and which culminated towards the close of the Palæozoic, were apparently less in degree here, than in many other areas, and the Palæozoic sediments in consequence are less disturbed. Still, the unconformities recognizable, and the tilting of the beds (though not usually great except near faults), are evidences of these movements.

These movements, continuous it may be said on a large scale, were subject to local interruptions here, as in Wales and elsewhere, and breaks in the succession are recognizable in consequence. One of these, between the lower conglomerates and sandstone series (Lower Cambrian), and the quartz-rocks and limestone series (Lower Silurian), is most marked. And I believe it will be found that there is another between the latter and the upper flaggy beds (these may possibly represent Middle and Upper Silurian). In the Pre-Cambrian area along the east side of Glen Laggan, extending up to and dipping under the shoulder of the hill, the prevailing rocks are a granitoid gneiss and some dark micaceous bands. (Notes 13 and 14.) The strike in these as already stated is from N.W. to S.E., and the angle of dip between 70° and 80°.

[Note 13.—This rock, although at first recalling to mind a graphic granite, does not appear on examination to belong to the graphic rocks, granitic or gneissic. It consists of quartz, orthoclase and a plagioclase, the little mica which it contains being in exceedingly thin laminæ and colourless. In thin section the quartz and felspar are seen to hold the same relations towards each other as in the more micaceous gneisses. Individual crystals of felspar are frequent, these are plagioclase and microcline. The mica is monochromatic.—T.D.]

[Note 14.—Is a dark bluish-grey, micaceous, foliated rock, very close-grained. Magnetite in minute octahedrons is disseminated throughout. A microscopic section shows very closely packed folia of biotite accompanied with a micro-crystalline mineral which is also dichroic, but not to the same extent as the biotite. Between these folia lie thickly interspersed the lenticular and banded groups of quartz. Sphene is abundant, also magnetite, and a few garnets are present.—T.D.]

The most characteristic of the overlying flaggy and schistose rocks, with a strike from N.E. to S.W., especially those which appear to have been most highly altered, are described in Notes 15—20.

[Note 15.—A compact, siliceous flaggy rock. Under the microscope shows quartz in rounded or subangular grains distributed in a very fine granular mass of the same, with a few fragments of a plagioclase. The schistosity here, which is very marked, is produced by the abundance of exceedingly minute individual laminæ (rarely groups) of a monochromatic micaceous mineral, the nature of which the microscope fails to establish, but it is probably a mica. Unlike its fellows in the gneisses, it appears to form a nearly omnipresent material between individual quartz grains, and is not separated into distinctive bands. Hence its eminently fissile character.—T.D.]

[NOTE 16.—Quartz in grains separated into nests and bands by very numerous wavy bands of muscovite. This constituent is also frequent as very minute laminæ between individual grains, as in No. 15, but is not so abundant as in that rock. The lamination characterizing these rocks is chiefly mechanical, and differs entirely from the banding of the gneiss.—T.D.]

[NOTE 17.—An exceedingly compact bluish-grey rock, with dull fracture, soft, and resembling some indurated shales. Thickly impregnated with exceedingly minute crystals of iron pyrites. It is difficult to obtain a section of this sufficiently thin for examination with the microscope. The ground-mass, grey in colour, is feebly translucent, and incloses much quartz in minute grains.—T.D.]

[NOTE 18.—This rock has considerable resemblance to No. 17, but is characterized by its greater abundance of angular, subangular and rounded quartz grains, which frequently separate out into lenticular nests. A little mica in exceedingly minute crystals is present. A schistose structure is given to it by the tendency of the indefinable ground-mass to assume the wavy condition which characterizes the micaceous constituent of the schistose quartzites.—T.D.]

[NOTE 19.—This appears to be a micaceous quartzite. It consists principally of closely aggregated quartz-grains, the outlines of which are distinctly shown between crossed Nicols. There are two micas, but they are not abundant. The one, markedly dichroic, is irregularly distributed in minute crystalline laminæ; the other, monochromatic, is in wavy continuous bands, breaking intermittently into lenticular groupings. The rock is traversed by veins of quartz, which is not distinguishable from that of the mass, but it contains no mica. A few fragments of felspar and rounded garnets are present, and also some crystalline nests of quartz. The detrital character of this rock is withal most marked.—T.D.]

[NOTE 20.—The macroscopical and microscopical characters of this rock are the same with those of No. 15, with the exception that here the indefinite micaceous mineral is somewhat more abundant.—T.D.]

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

V.—NOTE ON THE GEOGRAPHICAL DISTRIBUTION OF VOLCANOS.

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FROM what we know about the cooling of the earth and its geological structure, it would seem very probable that the principal features which we now see upon the surface of our planet, as, for instance, the continents and ocean-beds, received their forms in very early times, being, in fact, more or less a primary result of contraction. Since the formation of these impressions, contractions have continued to take place, and secondary results have come about, the character of which would appear in a great measure to be dependent upon the primary results by which they were preceded. Amongst the secondary results I would point to the position occupied by many volcanos.

If we take a map which shows the distribution of volcanos upon the surface of the globe, we shall observe that the greater number of these are situated in the vicinity of the oceans, and of these the most extraordinary range are those which circumscribe the Pacific. In the Atlantic and Indian Oceans, if we except the group of mountains which build up Iceland, there are comparatively but few. This remarkable distribution of volcanic vents has been noticed by many writers, who, whilst speculating on its meaning, have offered theories for its solution. To what has already been written, I now venture to offer a few additional notes.

First, we must observe that the Pacific Ocean, as compared with other oceans, as, for instance, the Atlantic, appears to be the deepest tract of water which covers the face of our planet.[1]

This would seem to indicate that the shores of the Pacific are steeper than those of the Atlantic; and that this is probably the case we can convince ourselves by examining the maps of a Physical atlas.[2]

If we do this, we shall see on the South American coast the Andes, some of the peaks of which are more than 20,000 feet in height, sloping down beneath a sea which is 12,000 feet in depth.

Along the North American coast the slope is not so great, because the Rocky Mountains, which form the high ground, lie farther inland.

In the Aleutians, the Kuriles, in Kamschatka, and in a great portion of Japan, the slopes are quite as great as they are in South America. In S. America the slope is great, because the mountains are high; but in these latter districts it is because the neighbouring sea is deep.

In Australia there is a very gentle slope. For the purpose of comparing together the various slopes we find upon the surface of the earth, I have drawn a large number of sections at right angles to coast-lines, each representing a length of 120 sea-miles, and having the same scales both vertically and horizontally, one end of these sections representing land beneath the sea, and the other end the land bordering on the coast. The following are a few of the slopes which I obtained upon various coasts.

On the west coast of South America, from Aconcagua, which is about 24,000 feet high, down into the sea, which is 2,000 fathoms in depth, the slope is about 1 in 20·2. In a S.E. direction, from

[1] According to Dr. O. Krümmel, the average depth of the Pacific is 3887 metres, whilst the Atlantic is 3681 metres.

[2] If we consider the mean height of the land which bounds the Pacific, and compare it with the mean height of that which bounds the Atlantic, we shall be brought to a similar conclusion. Some idea of what their heights would be may be obtained from the mean heights of the several continents, which are as follows:—

South America	1,132 feet.	Europe...	670 feet.
North America	748 feet.	Africa	1,600 feet?
Asia	1,150 feet.	Australia	500 feet?

Urup, one of the Kuriles, the slope is about 1 in 22·1. In an easterly direction, from the northern end of Nipon, the slope is about 1 in 30·4. From the Sandwich Islands towards the north there is a slope of 1 in 23·5.

The general slope on the coast of Australia is about 1 in 91, but on the S.E. shores, measured from the summit of Mount Kosciusko, a slope of 1 in 57 can be obtained. From Ben Nevis, the 120 mile slope, which will just reach to the 100-fathom line, is about 1 in 158. From the summit of the mountains of Southern Norway there is a slope of about 1 in 73.

In these few examples it will be seen that the 120 mile slope of the volcanic districts is about twice as steep as the slope in the districts which are free from volcanos.

Instead of taking a slope of 120 miles, we might regard the manner in which the land slopes beneath the sea more generally by drawing sections across the various continents, prolonging them beneath the sea, and then take their average slope. Suppose, for instance, we prolong the section of Aconcagua to the east coast, we shall find that whilst on the west coast we have a slope of about 1 in 20, to the east coast there is an average slope of 1 in 243.

Similar differences would be found between the slopes to the eastern and western shores of North America.

Without attempting to examine the various slopes upon the surface of the globe in detail, a general idea of them may be obtained by glancing over a map or chart showing the depths of the ocean and the heights of the adjoining land.

If this is done, it will be seen that volcanos are chiefly distributed along the borders of land which slopes *steeply* beneath the sea.

Now let us see what phenomena we might expect in connexion with these slopes.

First, going upon the assumption that although the world may in its interior be extremely hot, it is extremely rigid, a conclusion which is arrived at by Sir William Thomson and other eminent mathematicians and physicists, we see that we have downward pressures acting over the two ends of any of these 120 mile lines, of very different intensities.

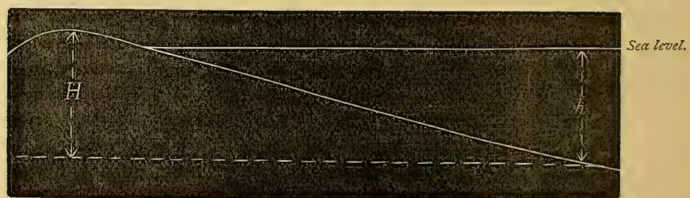

Fig. 1.

Over the end which is beneath the sea the pressure is that of a column of water *h*, very much less than the pressure of the larger column of rock *H*, acting downwards at the land end of the slope

(Fig. 1). If immediately beneath the crust of the earth we imagine a liquid material to exist, the pressure at H might be transmitted in the direction of h, and beneath this latter column we might expect a fracture to take place, and volcanic material to be thrown out. Under conditions like these, volcanos would be formed along a line parallel to a coast rather than on such coasts, the position where they actually occur. If, however, the rocks beneath the crust are solid, as we have supposed, this horizontal transmission would not take place, and therefore rather than along the line of weakest pressure, if fracture occurred it would be along the line of greatest pressure where the giving way would be experienced. On this supposition, the volcanos would be found upon the top of the slopes rather than at the bottom, and this, it is needless to remark, is where the greater number of them actually occur.

If we regard volcanic vents as having any connexion with the pressures exerted by the layers which form the crust of the earth, we see why they should rather be found at the upper end of a steep slope than near its foot. What I wish next to point out is the reason why volcanos are so often found at the upper end of a steep slope which *rises from beneath the sea.*

To commence with, let us suppose that for a long period, say for example 10,000 years, the hundred mile slopes of which I have spoken have had the same relative position to land and water as they have at present. This is almost equivalent to saying let us suppose that the Pacific Ocean and the continents surrounding it to have had pretty much the same relation to each other 10,000 years ago as they have now—a supposition which I do not think will meet with any serious objections.

Dana, in his Geology, p. 749, says—"As planes of equal temperature within the earth have a nearly uniform distance from the surface, the accumulation of sedimentary beds in the sinking trough would occasion, as Herschel long since urged, the corresponding rising of heat from below, so that with 40,000 feet of such accumulations a given isothermal plane would have been raised 40,000 feet."

The first portion of this argument I think is hardly just.

From experiment we know something about the isothermal surfaces beneath the land on which we live, but about the isothermal surfaces in the land which lies beneath the ocean we can only speculate.

Without entering into any calculations on the subject, it is not at all unlikely that, as in one case we have land cooling beneath an atmosphere and the compensating effects of a sun, whilst in the other case we have land cooling beneath water, which from all we know about deep-sea temperatures is usually very cold, we should find any given isotherm at a much greater depth beneath the rocks, which form the bed of an ocean, as compared with the depth at which we find it beneath the rocks which form the land.

The consequence of this would be that the ground beneath the bed of an ocean would be more rigid than beneath the atmosphere, and also that the region of rock at a fusing temperature would be nearer to the surface under the land area than beneath a sea area.

In the case where land slopes gently beneath the sea, as along the eastern coasts of North and South America, the inclination of any isotherm would be gentle and the decrease in thickness of the layer of surface rock which covers up and retains the more expansive rock beneath would be also gentle. In the case, however, where the 120 mile slope beneath the sea was steep, the thickness and consequent strength of the restraining cover would rapidly decrease as it ran up from beneath the sea towards the land.

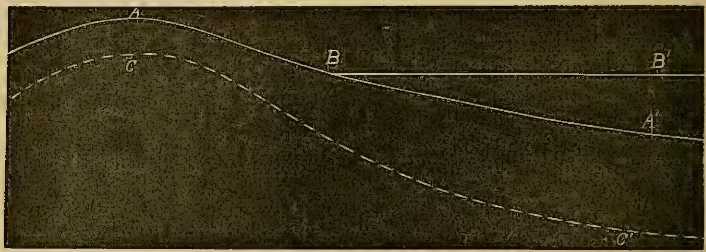

FIG. 2.—*CC'* is an imaginary isotherm when it passes from the land beneath the sea.

These conditions are shown in Fig. 2. *BB'* represents sea-level, *AA'* the surface of the land. The dotted line *CC'* an imaginary isotherm. Beneath this line we will suppose the rocks to be in a slowly viscous state. Above this line in a state sufficiently rigid to resist alteration of form. The load over the point *C''* equals the weight of the thick layer of superincumbent rigid rock plus the weight of a column of water. The load over *C* is only equal to the weight of a comparatively small layer of rigid rock. The layer of solid rock is something like the chain of a suspension bridge which is heavily loaded in the middle.

If conditions anything like this exist in nature, then we should expect to find lines of fracture and volcanic outbursts along any line of land which slopes down *quickly beneath the sea.* Where the high land from which the volcanos rise forms a ridge between two seas, as, for instance, is the case in Central America, we should have the chain of solid material, so to speak, hanging downwards on *two* sides, and thus it would be strained from two directions. A similar remark would apply to chains of islands like the Aleutians, the Kuriles, and those which form Japan.

When considering the position which isothermal surfaces probably occupy beneath the surface of the land, we must remember that whenever we get a contour which approximates to a reentrant angle, an isothermal surface will probably come nearer to the surface than it would at an upward bend in the earth's crust corresponding to a salient angle. Thus, if we had a plain from which a range of mountains suddenly rose up, we should expect at the junction of the plain with the mountains that an isotherm would be nearer to the surface of the ground than it would be at the summit of the range.

VI.—A Contribution to the Study of the British Carboniferous Tubicolar Annelida.

By R. Etheridge, Jun., F.G.S., F.R.P.S.Edin.

(*Continued from p.* 115.)

History of *Spirorbis* continued :—

In 1845 Dr. Dawson recorded the discovery, by himself, of *Spirorbis* on fossil plants from the Carboniferous sandstones of Tatmagouche, Nova Scotia.[1]

Dr. Bronn appears to have been the second to recognize the identity of Martin's *Conch.* (*Helicites*) *pusillus*, with Murchison's *Micro. carbonarius*, in which he has been followed by singularly few other writers.

Mr. E. W. Binney[2] has given us a very interesting paper on certain Carboniferous Annelide remains, amongst them Murchison's *Microconchus carbonarius*. Mr. Binney, in the first place, refers to the hitherto doubtful position occupied by this form, and proceeds to examine the arguments for and against its Annelide affinities. He notices the habit possessed by it of burrowing, or making for itself a depression in the substance of the plants of the Carboniferous system, and in the shells of various bivalves of the Coal-measures. Mr. Binney proposed to subdivide Murchison's genus *Microconchus* into *Spirorbis* and *Serpula*. Under the first he places the original *Micro. carbonarius*, Murch., describing it as attached to plants and shells, and gives a figure;[3] and another *Spirorbis*, a large species, named *S. omphalodes* by Portlock, referred[4] to that and perhaps identical with *Conch.* (*Helicites*) *pusillus*, Martin. The section *Serpula* comprises an uncoiled form, found in the Coal-measures, but not attached to plants, always free.[5] It is described as with irregular striæ oblique to the axis, and is named *Serpula carbonaria*, Binney.[6]

In 1853 E. F. Germar published[7] Prof. Göppert's description of a small, dextral or sinistral, shell-like body adhering to the fronds of *Sphenopteris acutifolia*, Brong., and also found separately on pieces of shale. These organisms, given under the name of *Gyromices ammonis*, Göpp., were known to Continental Palæontologists for many years as a Fungus (!), and were so described by Göppert and Germar; they are further described as possessing a septate character.

This view was continued in 1855 by Dr. H. B. Geinitz,[8] who noticed the habit possessed by the so-called *Gyromices ammonis* of burrowing into the substance of the plant on which it occurred, and its many-chambered nature.

Both the foregoing quotations have reference to the occurrence of

[1] Quart. Journ. Geol. Soc. 1845, i. p. 326.
[2] Mem. Lit. Phil. Soc. Manchester, 1852, x. p. 193.
[3] p. 196, t. 2, f. 3. [4] p. 196, t. 2, f. 4. [5] p. 196, t. 2, f. 2.
[6] This must not be confounded with *Serpula carbonaria*, Morris; *Spirorbis carbonarius*, Murch.; or *Serpulites carbonarius*, M'Coy.
[7] Verstein. Steinkohl. v. Wettin u. Löbejün. 1853, heft 8, p. 29 (III).
[8] Verstein. Steinkohlenformation v. Sachsen, 1855, p. 3.

G. ammonis in Carboniferous rocks, but according to the last-named authority it also passes to the Permian.[1] Dr. Geinitz figures it both dextral and sinistral on the fronds of *Cordaites ottonis*, and it is stated to occur both on and in the substance of the fern, and to be many-chambered; it is still called a Fungus. A point of some importance, bearing on its identity, lies in the fact that it is quoted by the author as occurring in Ireland.

In 1861 the late Mr. J. W. Salter gave an exceedingly good figure[2] of one variety of *Spirorbis carbonarius*, Murch., from the Coal-measures of South Wales, where it appears to be common, in certain strata. The variety figured is that with the prolongation forwards of the tube.

Dr. Dawson, in a paper "On the Coal-measures of the South Joggings," stated that the Nova Scotian *Spirorbis*, first noticed by him in 1845, closely resembled the *Microconchus carbonarius* of the British Coal-fields.[3]

In the same year Mr. Salter also definitely made known[4] the occurrence of *Microconchus carbonarius* in Scotch Carboniferous beds, although Hibbert's investigations had tolerably well established this point. Mr. Salter gave the Lower Carboniferous beds of the Clubbiedean Reservoir, near Edinburgh, as the locality and horizon of *M. carbonarius*.

So far as I am aware, the Chevalier d'Eichwald[5] has been the only writer, with the exception of, as before mentioned, Prof. Morris and Dr. Bronn, to call attention to the identity of *Micro. carbonarius*, Murch., with the earlier *Conch.* (*Helicites*) *pusillus*, Martin.

In a review of the occurrence of *Fungineæ* in Carboniferous rocks, Mr. Leo Lesquereux took occasion to refer to the *Gyromices ammonis*, Göpp., which he found in the shales over the coal at Colchester, Illinois, and elsewhere, attached both to the remains of plants and singly in the matrix. He described the chief features of the tube, and stated that internally it was hollow. Upon the whole, Mr. Lesquereux appears to regard it as a fresh-water mollusc.[6]

In the year following that in which the above was written, Mr. Lesquereux again returned to the subject of *Gyromices*, in a note to a paper "On the Coal Formations of America." It is usually found on the leaves and stem of *Callipteris Sullivani*, Lesq., and is still considered as a shell. Lesquereux believes the American, Nova Scotian and Continental forms to be identical, but the British is considered to be distinct.[7]

In 1864 Captain von Roehl,[8] in a communication to the Rhenish-Prussian Natural History Union, at Dorpat, stated that Redner compared the *Gyromices ammonis*, Göpp., to *Planorbis*, and considered it

[1] Dyas, 1862, heft 2, p. 133.
[2] Mem. Geol. Survey Gt. Brit. Iron Ores, 1861, pt. 3, t. 2, f. 23.
[3] Quart. Journ. Geol. Soc. 1854, x. p. 39.
[4] Mem. Geol. Survey Scot. No. 32, 1861, p. 145.
[5] Lethæa Rossica, 1860, i. p. 670.
[6] American Journ. Science, 1861, xxxii. p. 195.
[7] *Ibid*, 1862, xxxiii. p. 208.
[8] Naturhistorischen Verein d. Preuss. Rheinl. Verhandl. Dorpat, 1864, xxi. p. 43.

a Gasteropod, and identical with *Spirorbis carbonarius*, Dawson. This is probably one of the earliest instances of a change of opinion amongst Continental Palæontologists as to the affinities of *G. ammonis*, Göpp.

Writing in 1866, Mr. Leo Lesquereux, after having examined many specimens of the so-called *G. ammonis*, states that he "cannot consider them but as the small thick shells of an Annelid," and refers it to *Spirorbis carbonarius*, Dawson. The species, according to Lesquereux, is abundant at Colchester, Illinois, associated with the remains of *Callipteris Sullivantii*, *Pecopteris*, and *Stigmaria*, etc., and, as with us, leaving deep imprints on the plant surfaces.[1]

It is unnecessary to follow the figures of *S. carbonarius* by Murchison through the various editions of his "Siluria"; it will be sufficient for the purposes of the present history to notice only those of the fourth and last edition, published in 1867. The figures here given are the same as those used in the "Silurian System," and represent in a similar manner the British varieties of the species. The important point connected with these later references of Murchison is his recognition of the identity of his *Microconchus* with *Spirorbis*.[2]

Amongst the many occasions on which Mr. E. W. Binney has called attention to the present species, not the least important is that on which he described the position and extent of the "Spirorbis limestone" in the upper part of the Coal-measures of the North-west of England, where it forms a continuous and well-marked bed.[3]

We now come to an important paper by MM. Van Beneden and E. Coemans,[4] in which, following Von Roehl, they dispute the fungoid nature of the *Gyromices*, and endeavour, on their own part, to prove its relation to the Pulmonate Gasteropoda. MM. Van Beneden and Coemans assign to Dr. Andrä, of Bonn, the honour of being the first to doubt the vegetable origin of *Gyromices*. They consider it most nearly resembles *Planorbis*, or certain Tubicolar Annelides, and would be content to regard it as one of the latter, were it not difficult to reconcile the occurrence of marine forms of this class attached to the remains of terrestrial or fluviatile plants. From this, principally, they are led to look upon *Gyromices* as a Pulmonate Terrestrial Mollusc allied to the Helicidæ, living adherent to the stems and leaves of ferns and other coal-plants as the living *Spirorbis* does on marine vegetation and animals. Ignoring the term *Gyromices*, they propose for this the name *Palæorbis*.

In 1868 Major von Roehl gave a detailed notice of this species, and is one of the few German authors who has referred it to *Spirorbis*.[5]

In 1868 Dr. J. W. Dawson added to our knowledge of his *Spirorbis carbonarius*, by describing the microscopic shell structure,

1 Illinois Geol. Survey Rept. 1866, ii. p. 462.
2 Siluria, 1867, 4th edit. p. 302.
3 Trans. Manchester Geol. Soc 1866, vi. p. 42.
4 Bull. l'Acad. R. Bruxelles, 1867, 2me ser. xxiii.
5 Foss. Flora Steinkohlenf. Westphalens, lief. 1, p. 4.

which, he says, "is identical with that of the modern *Spirorbis*, and shows that it is a true worm shell." Dr. Dawson describes it as dextral, attached throughout its whole length, and with a deep umbilicus. "These little shells," he adds, "no doubt took immediate possession of submerged vegetation, just as their modern allies cover fronds of *Laminaria* and *Fucus*."[1]

As a sign of the abandonment of the fungoid nature of this much disputed little animal, we may take the opinion of Prof. Schimper in his "*Traité de Paléontologie Vegetal*," published in 1869. In the first volume *Gyromices* is placed amongst the doubtful Cryptogams,[2] and in the third volume the definite opinion is given, "I should see in it a shell rather than a fungus." In quoting Lesquereux's view, Prof. Schimper quite destroys the value of his opinion, for he causes the former to say he "cannot consider them as the small thick shells of an Annelid," the omission of the small word "but" before "as" making all possible difference in the sense and meaning of the quotation.[3]

My friend and fellow-labourer in the Edinburgh Palæontological field, Mr. C. W. Peach, gave, in 1871, an interesting account of the occurrence of *Sp. carbonarius* in the Burdiehouse limestone.[4]

In 1871 Dr. J. W. Dawson[5] again refers to and combats the notion of *Spirorbis* or *Gyromices* being a fungus. He describes a *Spirorbis* infesting the leaves of a Devonian plant, *Cordaites Robbii*, which is separated from the Carboniferous form on account of the more rapidly enlarging tube, under the name of *Sp. Erianus*. Dr. Dawson also states that the dextral or sinistral form of the tube often depends on whichever side of the leaf or plant is held up.

Messrs. Van Beneden and Coemans are supported in their views of the affinity of *Spirorbis* or *Gyromices*, whichever the reader chooses to regard it, by Dr. Goldenberg, who has recently written a lengthy essay on this form.[6] He compares it to *Planorbis*, asserts its molluscan affinity, and confutes the hitherto-accepted fungoid nature. On the whole his paper bears a very strong resemblance to that of the above authors; he, however, states that, from a comparison of specimens, he is satisfied Dawson's species found in America is identical with that occurring in the German Coal-fields.

The last reference to be made in the history of this much be-written, but little understood fossil is by myself.[7] In a paper published in 1878, on the Invertebrate Fauna of the Wardie shales, I briefly described *S. carbonarius*, and a variety to which I gave the name *Hibberti*, corresponding with the "*Nautilus*" of Dr. Hibbert. Its occurrence throughout the Wardie shales was traced and its relation to the other fossils pointed out.

(*To be continued.*)

[1] Acadian Geology, 2nd ed. 1868, p. 205.
[2] vol. i. p. 144. [3] vol. iii. p. 562.
[4] Trans. Geol. Soc. Edinb. 1871, ii. pt. 1, p. 82.
[5] Foss. Plants Dev. and Sil. Formations of Canada, 1871, pp. 43, 44.
[6] Fauna Saræpontana Foss. 1877, heft 2, p. 4.
[7] Quart. Journ. Geol. Soc. 1878, xxxiv. p. 9.

REVIEWS.

I.—Memoirs of the Geological Survey of England and Wales. The Geology of the Yorkshire Coal-field. By Prof. A. H. Green, M.A., and Messrs. R. Russell, J. R. Dakyns, J. C. Ward, C. Fox Strangways, W. H. Dalton and T. V. Holmes. Published by order of the Lords Commissioners of H. M. Treasury. Dated 1878, but not published until 1879.

THIS work, perhaps the most important economically of the Memoirs of the Geological Survey, is also the largest in size yet published, exceeding in bulk even Portlock's Report on the Geology of Londonderry. Intending purchasers, however, will be agreeably surprised to find that its price has not been fixed in accordance with the scale adopted in the case of some recent Survey Memoirs. Two guineas is the sum asked for this volume, containing 823 pages, 26 plates (chiefly sheets of comparative sections), and 125 woodcuts. Something might have been done to improve the appearance of the woodcuts, most of which have that shabby look almost peculiar now-a-days to Survey Memoirs; an appearance for which the original drawings are in no way to blame. An officer who finds his drawing treated as that for the frontispiece[1] of this book has been, can hardly look upon the result with satisfaction or even with equanimity.

No mention is made of the Derbyshire part of the Coal-field; the maps, on a scale of six inches to a mile, ending with the Yorkshire boundary. The country included in the memoir has therefore had the advantage throughout of the six-inch scale, which is absolutely necessary for good Coal-measure work. In addition, one-inch geological maps reduced from six-inch work are better in every respect than one-inch maps can otherwise be. The want of six-inch maps in the southern part of the great Coal-field is regretted by Prof. Ramsay, the Director-General of the Geological Survey, in his preface. But though eight years or more have elapsed since the completion of the geological fieldwork on the Yorkshire side, no steps have since been taken by the Ordnance Survey to give Derbyshire the advantage of six-inch maps.

Though the book is so large that it might well have been published in two volumes instead of one, there is scarcely a single superfluous sentence in it. The editor and chief contributor, Prof. Green, has done his work so well that it is a model of clear and concise arrangement and expression. There are four great chapters, each being subdivided into sections. The first chapter is short and introductory, and contains a brief sketch of the physical geography of the district. Remarks, also, are made on the degree of completeness possible in geological surveying, and its variation with the amount of evidence. Cautions are given as to the weight to be attached to the prolongation of faults across unproved country; and the desirability of borings in such places is urged, etc.

[1] The Reviewer's little boy, having caught sight of it, remarked its inferiority to the illustrations in the "Boy's Own Paper."

The second chapter consists of a lithological description of the rocks not of the Coal-measures only, but of the underlying Millstone Grit, Yoredale Rocks, and Carboniferous Limestone; by far the greater number of the 469 pages of which it is composed being devoted to the Coal-measures. It is of course utterly impossible to attempt any abstract of it; the mere table of contents would occupy more space than could here be spared.

Among other matters the rapidity with which the sandstones thicken and thin away is here noted. "Cases will be given where sandstones run with a fairly regular thickness of 100 feet or more over miles of country, and then wedge out to nothing in a space of half a mile or less." And their irregularity in composition or grain is noticed, together with the probable circumstances attending their deposition, which account for it. The existence in the coarser sandstones of lumps, and even crystals of orthoclase, only slightly decomposed, often gives the rock quite a granitic look, and may have been, the editor remarks in a note, the resemblance which led Charlotte Brontë into the mistake of describing the rocks of her native moors as granite.

The shales or binds also vary indefinitely, in composition, from those known as stone-bind or rock-bind, which may be called either sandy shales or shaly sandstones, to the purely argillaceous blue and soft binds. And these last are often darkened by the admixture of organic matter, till in some cases they become black, and pass by a gradual increase in the proportion of vegetable matter into impure cannel coals. These cannel coals are considered by Prof. Green to be exceptions to the rule that "the majority of the coals we have to deal with were certainly land-growths." He thinks that they, on the contrary, were formed under water, the plants of which they are composed having drifted into shallow ponds or lakes.

Before coming to the Coal-measures, the Millstone Grit is briefly dealt with, the circumstances of its deposition, and its local variations being noted. A general sketch of the Coal-measures precedes the detailed account, a course which renders the latter much more digestible.

The Lower Coal-measures, or beds between the Rough Rock and the Silkstone Coal, are intermediate in character between the Millstone Grit and Middle Coal-measures. Their sandstones are more massive, and their coals thinner than those of the latter. One rock, and one only, the Elland Flagstone or Greenmoor Rock, which belongs to the Lower Coal-measures, is traceable throughout the Coal-field, and makes therefore an excellent horizon.

The lowest bed of the Middle Coal-measures, the Silkstone Coal, is perhaps the most important of all the coals, the next in consequence being the Barnsley. The coals, though, on the average, much more persistent than the sandstones, vary considerably from place to place, and not unfrequently die away altogether. Both the Silkstone and Barnsley coals are traceable over the greater part of the Coal-field, and where they exist none others are worked. The tendency is therefore to avoid sinking pits at spots where there is any great thickness of measures above the Barnsley Coal, though many are sunk to the Silkstone at places below the outcrop of the Barnsley. This results in a concentration of coal-pits towards the western margin of the coal-field, and the existence of a large area of unproved ground towards the escarpment of the Magnesian Limestone, which is the more difficult to make out in detail from a greater variability in the sandstones coinciding with this dearth of colliery information. Among the uppermost of the Coal-measure beds, the most interesting is the Red Rock of Rotherham, which the labours of the Geological Survey have shown to lie unconformably on the beds below it. And on the other hand its Carboniferous age is shown by the presence above it, on the Midland Railway a mile south of Masborough, of beds of the ordinary Coal-measure type. No igneous rocks are found anywhere in the Coal-field.

The third great chapter occupies 270 pages of the book, and is divided into 38 sections. It deals with the present position and lie of the rocks. The country is divided into districts, each of which is treated by itself. The boundaries of these districts are either natural features, such as river-valleys or great escarpments; or geological lines, such as coal-crops or lines of fault. As in this chapter is given a detailed account of the geological and physical structure of the whole district, it is impossible to do more than simply mention it.

Chapter the fourth is concerned with glacial and river deposits, and occupies only 25 pages. There is an appendix consisting of a list furnished by Mr. W. Whitaker, F.G.S., of the books, papers and maps relating to the geology of the Yorkshire Coal-field and its neighbourhood, arranged chronologically: also a good index, the work of Mr. W. H. Dalton.

In conclusion, it must be remarked that it is a great pity that works such as the above should, from their advent not being sufficiently heralded by advertisements, and from neglect in sending copies for review, remain almost or quite unknown to many to whom they would be of the highest benefit. Government publications are no better protected than other literary productions from "wasting their sweetness on the desert air," in the absence of the proper means for making their existence known.—*Δ*.

II.—A Text-Book of Field Geology. By W. Henry Penning, F.G.S. With a section on Palæontology, by A. J. Jukes-Browne, B.A., F.G.S. Second Edition. 8vo. pp. 319, Geological Map, and twenty-nine Woodcuts. (London: Baillière, Tindall, and Cox, 1879.)

In the Geological Magazine for October, 1876, we called the attention of our readers to the "Field Geology" by Mr. Penning, then just published. We have now much pleasure in noticing the second edition of the work, which, with nearly one hundred additional pages, has become a good-sized volume. The new matter comprises further notes on the process of mapping, on levelling, and on the characters of the rocks to be observed in the field. In fact, the work bears evidence of careful revision throughout, and combines such full practical instructions that any student having mastered the principles of geology ought with this work in his hand to be able to do good field-work, whether in this country or in any distant land. Everything appears clear and intelligible enough for the beginner, excepting perhaps the diagrams on p. 66; in these, however, we are justified in finding faults. In table iii. p. 47, the Crag might have been added, for although it has not yet received an index mark in the Survey Table of Strata, at least one map showing the Crag (the country around Harwich) has been published.

In the section on Palæontology, Mr. Jukes-Browne has likewise added much new matter. And we notice that instead of the list of characteristic fossils, which in the former edition was arranged zoologically, so that from the fossil the geological position of the rock could be determined, we have now two tables, one of the characteristic genera belonging to each great division of the strata, whether British or foreign; and the other of the characteristic species for the chief sub-formations of each geological system in the British Isles and the western portion of Europe. Mr. Jukes-Browne's remarks on the testimony of the fossils are full and interesting. And we are led to think that after an attentive study of the work, few observers would attempt to describe the geology of any district, after making themselves acquainted with the characters of the rocks and the names of the fossils, without also making themselves acquainted with the practical mapping of the country, which alone can explain its stratigraphical features, and enable true pictures of the physical geography of each past period to be ultimately drawn.

III.—Report on the Geology and Gold-fields of Otago (New Zealand). By F. H. Hutton, F.G.S., and G. H. F. Ulrich. (Dunedin, 1875.)

THE general geological structure of Otago is similar to that of Westland and Canterbury, and of the twelve different marine periods, which, according to Captain Hutton, are found in New Zealand, only one, the Ahurni formation belonging to the Tertiary period, is altogether absent from Otago; one other, however, the Wanganuri (also Tertiary), is represented by lacustrine instead of marine deposits.

The formations belong to the Eozoic, Palæozoic, Mesozoic, and Tertiary periods, and are described in stratigraphical order, as regards their character, thickness, fossils, and contemporaneous volcanic rocks (when present), as well as their relation to the underlying formation.

Separate sections are devoted to the physical geography; the surface and economical geology of the province. A special report is furnished by Dr. Ulrich on the gold-fields and the occurrence of the metallic minerals of the province. Besides a geological map and sections, the work contains a table of altitudes, lists of the minerals, and of the vertebrate and molluscan fauna found in Otago. J. M.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—*Annual General Meeting*, Feb. 20, 1880.—H. C. Sorby, Esq., LL.D., F.R.S., the retiring President, occupied the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1879, from which it appeared that the same indications of depression which had been referred to in the previous year's report still continued, and that the finances of the Society were consequently not in so prosperous a condition as could be wished. The Council's Report mentioned the completion of the new Catalogue of the Library, the printing of which has been commenced, and announced that it would be issued to the Fellows at a low price.

The President said :—The Council has awarded the Wollaston Gold Medal to Professor A. Daubrée, of Paris, F.M.G.S., in recognition of his long and arduous work in geology, and especially for his researches on the formation of minerals and on the metamorphism of rocks. We must all regret that his pressing duties as President of the French Academy prevent his being amongst us to-day. Possibly no one of our members more highly appreciates his numerous contributions to physical geology than I do myself, since they have been so intimately connected with my own researches, though carried on in many cases in a very different manner. I would more especially allude to the great value of the experiments in which he was able to produce several very important minerals by the action of water at a high temperature; his researches on the formation of well-known zeolites in the old Roman brick-work at Plombières, and numerous other applications of the experimental method to the solution of other important questions connected with various branches of physical geology. These have culminated in his recent and most valuable work on experimental geology —a work which ought to be the means, as I trust it will be, of introducing and still further extending the experimental method of inquiry into all branches of our science.

The medal was placed in the hands of Mr. Bauerman for transmission, who in reply said that M. Daubrée desired to testify his gratitude to the Society not only for the honour done to him on this occasion, but also for the previous award of the Wollaston Fund in 1861, and more particularly for the kindly interest expressed by past Presidents, the late Sir Roderick Murchison and Mr. Leonard Horner, in the course of experimental researches then recently commenced, which had been a powerful encouragement to him in following out that particular line of work; and he was the more anxious to record this as these distinguished leaders of our science were no longer with us.

The President next handed the Murchison Medal and the proceeds of the Murchison Donation Fund to Mr. R. Etheridge, F.R.S., F.G.S. (the President-elect), and addressed him as follows:—

Mr. Etheridge,—In this room and before this assembly it is hardly necessary for me, in presenting you with the Murchison Medal, to enter into any explanations of the reasons which have induced the Council to award it to you. Your published writings, the greater part of which have appeared in our 'Quarterly Journal,' and must be well known and highly appreciated by most of us here present, would alone suffice to justify the Council in their award. But when we take into consideration your long-continued palæontological work in connexion with the Museum of the Geological Survey, the results of which have silently exerted so great an influence upon the progress of geology in this country, your constant help to others in their investigations, and your labours as a teacher in connexion with the School of Mines, which must have brought forth much good fruit, I think every one will acknowledge that you are fully entitled to all the honours which the Geological Society can confer upon you. I must refer especially to the valuable Catalogue of British Fossils upon which you have so long been engaged, to assist you in the completion of which the Council have joined to the award of the Murchison Medal the whole proceeds of the Fund for the present year.

Mr. Etheridge, in reply, said: Mr. President,—This is the second time the Council of the Geological Society has conferred upon me the honour of being one of its recipients. In 1871 I was presented with the balance of the Wollaston Fund; and to-day I receive, at your hands, evidence of the marked distinction and approbation of the Society in being selected to receive both the Murchison Medal and Fund. I am indeed gratified at being its present recipient. Sir Roderick Murchison was for fifteen years my esteemed chief and valued friend. I therefore attach especial value to this mark of your approbation of any labour that I have done in the cause of that science for which the Medal was founded. To me no labour in the field of natural science is too great to be devoted to carrying out those duties I have to perform; and the reward bestowed upon me to-day I hope still to merit and repay, through work yet to be done for our Society, and by aiding others to spread abroad the truths of Nature as taught through geological and palæontological research.

The President then presented the Lyell Medal to Mr. John Evans, D.C.L., LL.D., F.R.S., F.G.S., and addressed him as follows:—

Dr. Evans,—The Council has awarded to you the Lyell Medal and the sum of twenty guineas from the proceeds of the fund, in recognition of your distinguished services to geological science, especially in the department of Post-Tertiary geology. I can well remember the time when there appeared to be an almost impassable gulf between antiquaries and geologists; but you and your fellow-workers have so completely bridged over that gulf, that we now can scarcely say where archæology ends and geology begins, nor whether to rank and value you most as an antiquary or a geologist. Your long-continued labours and valuable writings on flint implements have equally advanced both the sciences to which I have alluded, and thrown great light on that most interesting problem—the Antiquity of Man. As another claim on our highest regard, I would refer to the great services you have rendered to this Society in every possible way that could advance its interests and that of our science. We feel assured that the founder of this Medal would have heartily approved of the award, since your researches have been so intimately connected with those subjects which in his later years attracted so much of his attention.

Dr. Evans in reply, said: Mr. President,—It is with much gratification that I receive this award at your hands, for I regard it not only as a kindly mark of appreciation on the part of yourself and the Council, but also as a memorial of my old and valued friend and master Sir Charles Lyell. This Medal, has, indeed, a peculiar interest to me in connexion with him; for it was while I was one of your Secretaries that he did me the honour of consulting me as to the foundation of this fund; and, subsequently, it was as your President that I had the satisfaction of handing the first Lyell Medal and the first proceeds of the Fund to no less distinguished a geologist and palæontologist than Prof. Morris. I am highly flattered to find myself associated with him and other eminent geologists in the list of the recipients of this Medal, and only wish that I was equally deserving of the honour. What little I may have done, either directly or indirectly, to promote the advance of geological knowledge, has been mainly the result of my now somewhat long connexion with this Society, and the many valuable and, I hope, enduring friendships with its Fellows that I have thus been enabled to make. This connexion is one upon which I look back with unalloyed satisfaction, and of which this Medal will always preserve the record.

The President next presented the balance of the proceeds of the Wollaston Donation Fund to Mr. Thomas Davies, F.G.S., of the British Museum, and addressed him as follows:—

Mr. Davies,—The Council of this Society has awarded to you the balance of the proceeds of the Wollaston Fund, as a testimony of the value of your researches in mineralogy and lithology, and to assist you in the further examination of the microscopic structure of rocks. I need hardly say how much this subject claims my own sympathy, and we feel assured that it would also have secured that of the founder of the fund. I am astonished at the rapid growth of this branch of inquiry since, some thirty years ago, I with my own hands prepared the first thin sections of rocks for geological purposes. Very much, however, remains to be learned; and we hope that the award of the Council will enable you to still further extend your inquiries. Valuable as have been the results which you have made public, we all feel that in many cases you have still further advanced our science by the generous assistance which you have afforded to others. As a slight token of our regard, we beg you will accept the usual balance of the Wollaston Fund, which I now present to you.

Mr. Davies replied: Mr. President,—I am deeply sensible of the honour conferred upon me by the Council in making me this award, and I beg to tender them my sincere thanks. That branch of the science of mineralogy which embraces the habits, associations, and modes of occurrence of mineral species has long been of special interest to me. The gratification derived from having been enabled to apply the knowledge I have gained in assisting others to elucidate the structure and probable origin of some of the older rocks, is now greatly enhanced by this recognition. I regard it also as an incentive to the continuance of this work, which now occupies so many scientific minds both at home and abroad.

Addressing Professor Seeley, the President said:—It is with much pleasure that I hand to you the balance of the proceeds of the Lyell Donation Fund for transmission to Prof. Quenstedt, of Tübingen, F.M.G.S., to whom it has been awarded by the Council of the Society. Prof. Quenstedt's labours in various departments of geology, extending over a period of more than five-and-forty years; his published writings, commencing with memoirs on mineralogical subjects in the year 1835, followed very shortly by others dealing with palæontological matters, culminating in his admirable Manuals of Palæontology and Mineralogy, published respectively in 1852 and 1854, and of which several later editions have appeared,—in his great work 'Der Jura,' on the Jurassic rocks of Southern Germany,—and in his magnificent 'Petrefactenkunde Deutschlands,' commenced in 1846, and still in progress; his renown as a successful teacher of geology and mineralogy; and his services to science by the establishment of the fine Museum over which he so worthily presides at Tübingen, have already been recognized by this Society in his election as a Foreign Correspondent in 1863, and as a Foreign Member in 1875. It is with the purpose of showing their continued appreciation of these labours, and especially to aid the distinguished Professor in the completion of his last-mentioned great work, that the Council have decided to award to him the balance of the Lyell Donation Fund; and in placing it in your hands I have to beg that you will request his acceptance of it in the spirit in which it is offered.

Professor Seeley, in reply, said,—I am sure that Professor Quenstedt will gratefully appreciate the terms in which you have expressed, on behalf of the Geological Society, admiration for his great efforts to advance geological science. Upwards of seventy years of age, he is labouring with the energy of mature powers; but with unaffected modesty expresses to me astonishment that his work, which is still unfinished, should have been thought worthy of this award. The fact that the Fund is associated with the name of the great master Sir Charles Lyell gives it for him an additional value; for so far back as 1857 Sir Charles sent to Prof. Quenstedt his own clinometer, and in many ways in after-years gave evidence of sympathy with the investigations of the distinguished teacher of Tübingen. I may say that in these days of division of labour one thinks with wonder of the variety of Prof. Quenstedt's work, signalized as it has been by success in every department. The perfection of his work may, perhaps, be summed up in the one word "thoroughness," for it begins with an almost unrivalled development of the treasures in his wonderful museum, and culminates in the rare courtesy and singleness of heart with which he communicates to others the treasures stored in his mind. I am sure he will gratefully accept this award in the spirit in which it is offered, and for the further advancement of science.

The President then proceeded to read his Anniversary Address, which was devoted to an examination of the structure and origin of non-calcareous stratified rocks, especially as revealed by microscopic investigation, and to a consideration of certain phenomena of their metamorphism, the production of cleavage, etc. The Address was prefaced by obituary notices of Fellows and Foreign Members of the Society deceased during the past year, including Prof. Paul Gervais, Prof. Bernhard von Cotta, Mr. David Page, Prof. James Nicol, Sir Walter C. Trevelyan, Bart., Mr. John Waterhouse, and others.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President:* R. Etheridge, Esq., F.R.S. *Vice-Presidents:* Sir P. de M. Grey-Egerton, Bart., M.P., F.R.S.; John Evans, D.C.L., LL.D., F.R.S.; J. W. Hulke, Esq., F.R.S.; Prof. A. C. Ramsay, LL.D., F.R.S. *Secretaries:* Prof. T. G. Bonney, M.A., F.R.S.; Prof. J. W. Judd, F.R.S. *Foreign Secretary:* Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer:* J. Gwyn Jeffreys, LL.D., F.R.S. *Council:* Rev. J. F. Blake, M.A.; Prof. T. G. Bonney, M.A., F.R.S.; W. Carruthers, Esq., F.R.S.; Sir P. de M. Grey-Egerton, Bart., M.P., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, D.C.L., LL.D., F.R.S.; Lieut.-Col. H. H. Godwin-Austen; J. Clark Hawkshaw, Esq., M.A.; Henry Hicks, M.D.; W. H. Hudlestone, Esq., M.A.; Prof. T. McKenny Hughes, M.A.; J. W. Hulke, Esq., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Prof. T. Rupert Jones, F.R.S.; Prof. J. W. Judd, F.R.S.; Prof. N. S. Maskelyne, M.A., F.R.S.; J. Morris, Esq., M.A.; J. A. Phillips, Esq.; Prof. J. Prestwich, M.A., F.R.S.; Prof. A. C. Ramsay, LL.D., F.R.S.; Prof. H. G. Seeley, F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S.; H. C. Sorby, LL.D., F.R.S.

II.—Feb. 25, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Geology of Anglesey." By Prof. T. McKenny Hughes, M.A.

The author brought forward evidence to show that, resting on the central gneissic axis of Anglesey, there was a series of conglomerates which he referred to the base of the Cambrian; that the Lingula-flags had not yet been recognized; that the conglomerates were followed by the brown sandstones hitherto referred to Caradoc, but which he identified by the included fossils with Tremadoc; that the lower part of the Black-Shale Group was Arenig, as shown by the Graptolites; while he thought that the higher parts of the Black-Shale Group might turn out to be Lower Bala; that the Black Shales pass under the Gnarled Schists. He then adduced evidence to show that these Gnarled Schists were not foliated or in any way true metamorphic rocks, but only crumpled laminated beds, in which all the alteration that had taken place was of the nature of vein-structure, and a kind of universal slickenside, consequent upon the crushing of a rock consisting of thin laminæ of different texture; and suggested that the whole might be, like the green slates, etc., of Chapel-le-dale, in Yorkshire, the water-sorted out-lying equivalents of volcanic rocks elsewhere, and be contemporaneous with the Snowdon volcanic series.

2. "Notes on the Strata exposed in laying out the Oxford Sewage Farm at Sandford-on-Thames." By E. S. Cobbold, Esq., F.G.S., Assoc. M. Inst. C.E.

The beds noticed in this paper belong to the Kimmeridge Clay and the upper and middle part of the Oxford Oolite. They were exposed (over an area of about 1½ mile by 1 mile) in making deep trenches for a sewage farm, about four miles S. of Oxford. The author described variations in the Coralline Oolite and Coral Rag, which become, in places, a marl without corals. The Calcareous Grit also is variable in character. On either side of this tract, at Headington and Cumnor, are coralliferous strata. Thus it appears to indicate a gap in the reef. The clay may indicate the proximity of some river, which thus caused an interruption. The author gave reasons for thinking that it came from the S.E., and suggested that it may have descended from the Palæozoic ridge beneath London. The paper also included some notes on the Kimmeridge Clay and a peat deposit.

3. "A Review and Description of the various Species of British Upper-Silurian Fenestellidæ." By G. W. Shrubsole, Esq., F.G.S.

In this paper the author passed in review the forms of Fenestellidæ which have been described from British Upper Silurian rocks. These amount to nine in all—six described by Lonsdale, two by M'Coy, and one by Portlock. From the imperfect condition of the specimens at the command of these authors, and especially from their characters being masked by an incrusting growth of corals, etc., and by subsequent matting, it is in most cases impossible to identify them; only one of the nine species, namely *F. rigidula*, M'Coy, being recognizable. The author discusses the peculiarities of these supposed species, of which he adopts only *F. rigidula;* and describes the other forms known to him under the following new names:—*Fenestella reteporata*, *F. lineata*, and *F. intermedia*. The author further discussed the relations of the Silurian Fenestellidæ to those of the Carboniferous and to other organisms.

III.—March 10, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communication was read:—

"On the Geological Relations of the Rocks of the South of Ireland to those of North Devon and other British and Continental Districts." By Professor Edward Hull, M.A., LL.D., F.R.S., F.G.S., Director of the Geological Survey of Ireland.

In this paper the author, after referring to his previous paper on the geological age of the Glengariff beds (Quart. Journ. Geol. Soc. vol. xxxv. p. 699), in which he showed that between them and the succeeding Old Red Sandstone in the south of Ireland there existed a very great hiatus, proceeded to compare the sections of the rocks of the south of Ireland with those of North Devon, and to show that the hiatus in question is represented in the latter locality by the whole of the Middle and Lower Devonian rocks. He then discussed the relations of the Devonshire rocks to those occurring north of the Severn, in Scotland, and in Belgium; and from this review of the whole question he arrived at the following conclusions:—First, that there is only one Old Red Sandstone properly so-called—represented in Devonshire by the Pickwell-Down Sandstone; in Ireland by the so-called Upper Old Red Sandstone, including the Kiltorcan beds; in Scotland by the so-called Upper Old Red Sandstone; and in Belgium by the "Psammites du Condroz." Secondly that the so-called Old Red Sandstone of Herefordshire is the estuarine representative of the Middle and Lower Devonians of Devonshire; and that the so-called Lower Old Red Sandstone of Scotland, with its fish-remains, is the lacustrine representative of the Upper Silurian rocks. In conclusion, the author discussed the physical conditions under which these various formations were deposited.

CORRESPONDENCE.

THE AGE OF THE PENNINE CHAIN.

Sir,—When Mr. Wilson asserts that I have assailed two of his arguments, I beg of him to recollect that he is the assailant; I the defendant.

Both Mr. Harris Teall and Mr. Wilson maintain that between the Permian and Trias there is no important *hiatus* or unconformity. I am aware that this has for some time past been an article of faith with some Nottingham geologists, who are content to take the geology of the Nottingham district as a synopsis of that of the whole of England, if not of the British Isles and Europe. Mr. Wilson now admits, what I had previously suspected, that he has no personal knowledge of the Permian beds of Lancashire—at least not those of the Stockport district; and I would venture to recommend him, before proceeding further with this subject, to run over to that not very distant region, and examine the sections in that district, which he will find fully described in the Survey Memoir on "The Geology of Stockport, etc.," pp. 33-5. He will then find—1st. That there is a decided unconformity between the New Red Sandstone and the Lower Permian Sandstone—inasmuch as the Permian Marls with limestones, which are almost overlapped at Stockport (allowing the New Red and Permian Sandstones to come into contact), are separated at Hope Hall by 25 feet, and at Heaton Mersey by 129 feet of Upper Permian marls with limestones.

2nd. He will find that in supposing the Permian Sandstones on the west of the Pennine ridge to be represented by such beds as the "Red Rock of Rotherham," he has been (to use his own expression) "singularly unfortunate" in his controversy with me at least. Both Mr. Teall and Mr. Wilson ought to recollect that, as regards the age of the sandstones of Stockport, Collyhurst, and other places in Lancashire and Cheshire, their Permian age and unconformity to the New Red Sandstone has been proved repeatedly by Mr. Binney; and the views of myself, as representing to some extent the Geological Survey of that district, are simply in corroboration of Mr. Binney's very able statements.

Now I must again press my point. How can my opponents account for the absence of beds of shingle in the Permian sandstone of Stockport and East Cheshire, if the Carboniferous rocks formed a ridge at the time of their deposition?

Mr. Wilson asserts that "geologists, not omitting the Survey authorities," have long since abandoned the belief in the Permian age of the Lower Red Sandstone of Yorkshire and Durham," and amongst the authorities for this statement I am referred to the able Memoir on the Yorkshire Coal-field, p. 482. On turning to the Memoir, I find that the sandstones here referred to are "the Red Rock of Rotherham," which, in accord with the authors of the Memoir, I regard (and for a long while have regarded) as an upper member of the Coal-measures. This will be seen on reference to my paper "On the Upper Limit of the Essentially Marine Beds of the Carboniferous Series,"[1] where this and the "Ackworth rock" are placed in my Carboniferous "Stage G." It is therefore futile to controvert a point which has never been asserted, at least by myself. The Lower Red Sandstone of truly Permian age is an entirely different rock, both in geological position and character. Whether in Lancashire, Cheshire, or Durham, it is quite unlike the Upper Coal-measure Sandstones, and it never occurred to me to confound the two together, as has been done by Mr. Wilson. Again, on referring to Professor Ramsay's paper, "On the Triassic and Permian Rocks," it seems to me that his statement refers in a large measure to the Upper Coal-measure Sandstones of Yorkshire and Derbyshire, above described; but in any case it will be found, on referring to the recently published 6-inch maps of the Durham District, that the Lower Permian Sandstone is distinctly marked at intervals along the margin of the Magnesian Limestone, under the designation of "Yellow Sand." Besides, neither in the paper referred to, nor in the new edition of the "Physical Geology of Great Britain" (1878), does Professor Ramsay throw any doubt upon the age of the beds represented in Lancashire by Mr. Binney and myself as of Permian age; and as regards the question under discussion this is the essential point. I repeat, therefore, that allowing for the distance by which they are separated, the Permian beds on either side of the Pennine Chain are sufficiently similar in position, character, and succession, to admit of the probability that they were originally continuous. This probability is reduced to a certainty by the identity of the fossils, of which Mr. Wilson seems to take little account.

Mr. Wilson has referred to the results of the Scarle boring. Now, assuming the Carboniferous rocks which were reached to be those of the uppermost Coal-measures, and lying 2,000 feet (as Mr. Wilson supposes) above the highest beds cropping out along the borders of the Magnesian Limestone in Derbyshire, the distance being thirty-five miles, has Mr. Wilson calculated what the dip would be? He will find that about 1° will be a sufficient angle to bring them in. Now, I have never denied that the Coal-measures *have* a slight dip in relation to the Permian beds; but I say this may be an older tilting than that which upraised the Carboniferous rocks of the Pennine Chain.

In reference to the general question of the relations of the Triassic and Permian rocks, I am at variance with the views of both your correspondents. I think I may claim to have a much larger personal knowledge of the relations of these rocks over the central and northern counties than either Mr. Wilson or Mr. Teall, having spent from ten to a dozen years in mapping them. Knowing also the geology of Nottingham from personal examination, and from the observations of others, I have no hesitation in saying that the relations of these two formations in that very district prove distinctly their mutual unconformity. In other districts this unconformity is

[1] Quart. Journ. Geol. Soc. Nov. 1877, p. 627.

often more clear and trenchant—so much so that those fathers of British geology who made a separation between the Palæozoic and Mesozoic groups exercised a wise discretion in making the division at the junction of the two formations. This physical break is represented by the remarkable change in the fauna and flora of the formations on either side of the boundary, a fact which I fear neither of your correspondents has sufficiently considered.

EDWARD HULL.

THE AGE OF THE PENNINE CHAIN.

SIR,—Having given some attention during the past few years to the Permian Formation in the North-east of England, I should feel obliged if you would allow me to say a word or two on the above subject. I can corroborate all that Mr. E. Wilson has said with respect to the physical break which exists on the north-east side of Pennine Chain between the Permian and Carboniferous formations; for at some of the new collieries which have recently been put down through the Permians in the Nottingham and Derbyshire Coal-field, the difference in dip nearly amounted to twenty degrees, whilst in every case the unconformability between the two formations was most marked.

The westerly attenuation of not only the Marl Slates but of the Permian Formation as a whole, and the sedimentary materials with which on the west it is intermingled, point to the existence of high ground in that direction during Permian times; whilst the great differences which undoubtedly exist in the character and thickness of the same formation on both sides of the existing anticlinal are facts altogether in favour of its existence at the time these deposits were laid down. I remember the surprise quite well which Professor Hull expressed when the Scarle boring proved the Permians to attain such a vast thickness in that locality, and the difficulty he experienced in recognizing the Marl Slates (about 150 feet in thickness), which he afterwards placed in the Carboniferous system.

Under these circumstances, I fail to see how Professor Hull and Mr. Teall can object to the existence of the Pennine Chain during the deposition of the Permian formation, when such reliable facts in support of such an existence can be produced.

MEXBOROUGH, near ROTHERHAM. ROWLAND GASCOIGNE, F.G.S.

CRETACEOUS GASTEROPODA.

SIR,—Mr. Wm. Gault, of Belfast, now engaged in compiling a list of the Irish Cretaceous fossils, has kindly forwarded to me for examination those which appeared to be Limpets and Dentalia. The result has proved that the Irish species, hitherto known as *Dentalium septangulare* of Fleming, is really an Annelid. Mr. Etheridge and Prof. Morris agree with me in this opinion, but it is especially to Dr. Gwyn Jeffreys that I am indebted for a most critical examination. He states regarding them—"They differ from the Solenoconchia and agree with the Testaceous Annelida in the following particulars. They are much more solid and more curved, and the mouth or aperture is decidedly constricted. The microscopic structure showing the lines of periodical growth or accretion is such as occurs in Annulose and not in Molluscous shells. One of the specimens contains a *Ditrupa* and a *Spirorbis* both of which exhibit precisely the same kind of microscopic structure."[1]

While some of the supposed patelliform shells cannot be placed among the Mollusca, one form, of which there are two specimens, is very well preserved and distinct. It is referred by Gwyn Jeffreys to the genus *Hipponyx*, of which no upper valves were known previously from any strata below the Maestricht Limestone, although the lower valves or shelly bases had been met with in both the Chalk and Greensand in England.

They are from the Glauconitic Marls of the Black Mountain, Belfast, from the zone of *Pecten asper* of Barrois.

I have also received within the past week a new *Emarginula* from the Grey Chalk near Folkestone, which differs markedly from the only form hitherto known, *E. Gresslyi*, from that locality. I hope to illustrate both these in a future number of the Geological Magazine.

J. Starkie Gardner.

COMPARATIVE PHYTOLOGY.

Sir,—Some very indistinct impressions, or rather remains of leaves, were forwarded to me from the well-known hazel-nut bed of Brook in the Isle of Wight, under the supposition that they might prove to be leaves of the beech. It is interesting to record that Baron von Ettingshausen found himself able to at once pronounce them to be leaves of *Corylus*, although he was quite unaware that they had been found associated with the nuts, and therefore recognized them entirely from what could be traced of their venation, for the outline and margin were almost wholly obliterated. J. Starkie Gardner.

THE TERM "SCHIST."

Sir,—I feel rather perplexed by some observations on the term "schist" made by Mr. Allport in the Geol. Mag. for this month. A great deal of confusion at present prevails as to the exact meaning of the word, and the progress of our knowledge, as I know by experience, is impeded by the want of a fixed meaning. Following Jukes, I have usually confined the terms "schist" and "schistose" to a rock possessing true foliation, as defined by Darwin, and approved by Mr. Allport. But when I have come to study certain "schists" in the field, I have found them to be simply laminated or cleaved, and therefore not schists, but shales or slates. It has appeared to me that we could not do better than adhere to Jukes's summary of the different kinds of fissile structure: "the *foliation* of *schist*, the *cleavage* of *slate*, and the *lamination* of *shale*." I was accordingly cast in doubt on finding that so high an authority as Mr. Allport used "schistose" as equivalent to "fissile," and affirmed that "the term schist certainly ought not to imply or include foliation." I confess I do not see why the word "fissile" could not be used for rocks which do not come into Jukes's triad, leaving as "schistose" undecomposed and unmetamor-

[1] See Dr. Gwyn Jeffreys's report of the *Valorous* Expedition, Proc. R.S. 1876.

phosed. I write, however, less as a critic than an inquirer; and for any petrological autocrat or parliament who will fix our nomenclature, I will, as in duty bound, for ever pray. C. CALLAWAY.

WELLINGTON, SALOP, *March* 4, 1880.

THE GLACIAL DEPOSITS OF CROMER.

SIR,—If Mr. Reid had extended his observations he would possibly have suppressed the paper which appeared in your pages of last month. Geologists will find the refutation of it in the structure of the Wensum Valley by Foulsham, Guist, and Fakenham, where the beds of the Cromer Cliff have been cut through by this valley, into which the chalky clay in its unmistakable form has come, resting on the Middle Glacial (a later part of it than that which caps the Cliff section), near the valley bottom, but wrapping over this and lying upon the Till and Contorted Drift direct on the higher slope of the valley. The instances, however, of the excavation of valleys through the older Glacial beds and Crag, and their infilling by the gravel and chalky clay, are universal wherever the Contorted Drift extends, and occur as far south as the southern border of Suffolk.

The gentlemen of the Survey, confined by their duties to very limited areas, form some of them very decided opinions upon the whole subject of the newer Pliocene formation from what they find there. Thus from a gentleman employed in Cambridgeshire and West Essex we have been presented with one theory of the Glacial formation; from another who was employed in the neighbourhood of the Fen country we have a most elaborate theory of it, which in most respects is the exact contrary of the former; and now we have Mr. Reid's. From gentlemen unconnected with the Survey we have had that of Mr. Gunn, who finds everything — upper, lower, middle, "the great laminated series," and I do not know what besides,—in the Cromer Cliff; that of Mr. Geo. Maw, who made out that the beds of the Cromer Cliff were posterior to the chalky clay, and analogous in position to that part of this clay which Mr. Harmer showed, in 1866, lay in valleys cut through its general outspread; and that of the late Mr. Belt, which was so vast and extraordinary as to be beyond definition here; and besides these, there are my own more moderate views. The principal result of this excogitation must be that geologists in general infer that we are all quite in the dark, and I suspect are, many of them, laughing at us.

Dr. Croll has in your pages insisted that the Glacial Clay of Holderness, which is without contortions, and contains numerous horizontal beds of sand or gravel, is the bed of the North Sea between England and Scandinavia shoved bodily over Yorkshire by the Scandinavian ice; and this, moreover, without disturbing the Chalk floor. Mr. Reid now has it that this ice has shoved Norfolk out of its place (still without disturbing the Chalk floor) and crumpled up the county. Beside, and in contrast with these hypotheses, we have Mr. Geikie and Mr. Skertchley insisting that the morainic clay, which is seen for miles overlying sand and gravel in the North Suffolk cliff, has been dragged thus over by the ice, without even the layer of sand actually in contact with it being disturbed. These things are so far beyond my feeble powers of comprehension that all I can do is reverentially to take off my hat to these several gentlemen, and subside; maintaining, nevertheless, that the delineation given by Mr. Harmer and myself in 1871 of the beds of the Cromer Cliff is (subject to the clearing up of what may be involved in the unconformity in the midst of the Lower Glacial of the cliff at Hasborough, and eastwards of that place, to which we called attention by sections and remarks) quite correct, Mr. Reid's many subdivisions notwithstanding; as is also the age and position of the beds of the Cromer Cliff section, relatively to the chalky clay that we assigned to them. As regards the mode in which the morainic clay was laid over the sand, I have in a paper sent in to the Geological Society, and now awaiting its turn for reading, given my view.

Searles V. Wood, jun.

DR. CROLL'S ECCENTRICITY THEORY.

Sir,—May I be allowed to suggest to Dr. Croll that he should offer some explanation how the glaciation of North America, as compared with that of Europe, is to be reconciled with his theory. The difference between the Eastern side of North America and that of the west of Europe is admitted to be the result of the ocean currents now existing; but the glaciation of the two regions was merely an equal increase of the cold in both, without change in their relative proportions; the same differences which now exist being shown by the limit to which glacial evidences extend in both regions to have obtained during that glaciation.

This, as I have on more than one occasion observed, appears to me to be a conclusive objection to Dr. Croll's theory, which he admits to be baseless unless there were a complete diversion of the warm ocean currents from the hemisphere glaciated; and its satisfactory removal would to my mind be worth any amount of those subtle reasonings on the physics of heat in which Dr. Croll is so fertile, but which seem to me to be obnoxious to the reproach often levelled at figures, viz. that they may be made to prove anything. Searles V. Wood, jun.

ECCENTRICITY AND GLACIAL EPOCHS.

Sir,—Dr. Croll in his article in February last speaks of an erroneous assumption, that if the annual receipt of heat be far more than sufficient to melt the annual snow-fall, then such snow must be melted.

He does not point out wherein the error lies, and I feel very doubtful whether I understand what he is referring to. The assumption, he says, is totally opposed to the known facts of Greenland. This statement seems rather too strong. He quotes Meech's calculation that the heat received there, neglecting that cut off by the atmosphere, is enough to melt 50 feet of ice. We must make allowance for the great thickness of air traversed by the sun's rays, and for the loss of heat by the great obliquity of reflexion. A very rude calculation, with no pretence to accuracy, brings out that these reduce the heat received by the ground, to sufficient for melting only some 16 feet of ice. Since to vaporize ice requires $7\frac{1}{2}$ times as much heat as to melt it, this would dissipate by evaporation only little more than two feet annually. But the annual precipitation amounts to one foot. If we suppose this to be formed during the winter, then the heat given off in winter by radiation is as much as would evaporate one foot.

Radiation goes on in summer as well as in winter, indeed more actively, as then temperatures are higher. This has to be compensated out of the heat then being received. Thus, out of the heat received during summer, as much as will evaporate more than one foot of ice is spent simply in replacing the heat being radiated away. The heat ultimately left will scarcely be sufficient to evaporate the one foot of ice which we had to account for. Thus even neglecting the effects of the fall of temperature far below freezing-point in winter, the interception of solar heat by fogs in spring, and other possible causes, it is still conceivable for the calculated heat to fall on Greenland, and yet not dissipate so much as the observed amount of ice.

The above calculation gives some idea of the diverse results which may be obtained when we reason on uncertain assumptions. The heat given off in forming a foot of snow or ice out of vapour, if applied to changing snow or ice back merely into water, would liquefy nearly eight times as much. Whether solar heat would melt or evaporate the ice into which it entered probably depends on the dryness or dampness of the air. This suggests, what I have often thought probable, that to know better the laws of winds might be very helpful in the study of Glacial Periods.

The suggestion of Dr. Roberts's lucid letter, that the heat disengaged in the formation of snow, being disengaged in the upper regions of the air, produces little effect at the ground, is well worthy of consideration. The same is probably true of rain, and over not merely Arctic regions but the whole surface of the globe. But to make this action available in support of the theory under discussion, we must show that its effect can be increased by increase of eccentricity. It is not sufficient to prove that it is intensified by rising temperatures, unless it also be shown not to be correspondingly enfeebled when they fall. This remark applies to many suggested actions. Eccentricity when it seems to throw a sword into one scale, often places in the other scale a shield.

E. Hill.

THE KURILE ISLANDS.

Sir,—The following notes upon the Kurile Islands were obtained from Mr. J. Snow, a gentleman who has spent several summers cruising amongst this interesting group of volcanos, whilst engaged in otter hunting. I offer them to you as supplementary to what I wrote upon these islands myself in 1878 (see Geological Magazine, Decade II. Vol. VI. pp. 337—348).

Chirnoi Islands.—On May 29th, 1879, smoke or steam was seen to be issuing from the northern of these two islands. It is possible that the eruption may have commenced before this date. On the 30th, at intervals of from ¼ to ½ an hour, loud explosions were heard. During the night the mountain was seen to be covered with fire. The eruption seems to have formed a new point of land. On the island there are four cones, all of which give off steam. Of these four, the most northern one is the highest. It was the two smaller ones which erupted this year.

Iturup.—At the south-west end of this island there is a mountain which was seen to give off steam for the first time in 1879.

Simusir.—At the south end of this island there is a mountain which gives off steam.

Ushishir.—From this island a little steam is given off.

Rashua.—This island also gives off a little steam.

Shaiskotan.—Not only does steam issue from the north-east end of this island, but it also issues at the south end. The state of activity appears to be greater than on Simusir, but less than it is on Chirnoi.

Kharim Kotan.—This island gives off a little steam.

Onekotan.—A little steam is given off from the mountains at both ends of this island.

When I wrote about the Kurile Islands, I only mentioned nine mountains, which were seen to be giving off steam. The numbers of such mountains will now be increased to 17. Of well-defined volcanic peaks I saw fifty-two. Forty-three of these were at that time (1878) apparently extinct. From Mr. Snow's observations we now see that several of these shortly afterwards, that is, in 1879, became active. The number is in fact variable, and, for aught we know, the number of active cones in the Kurile Islands may at the present moment be different from what it was when I was there, or when Mr. Snow was there. We have in fact in the case of the Kurile Islands a remarkable example of the futility in attempting to enumerate the number of active cones in any given area. The number is ever changing, but on the whole it is probably growing less. It may roughly, perhaps, follow some law analogous to a rate of cooling. For any one short period we may perhaps determine the number approximately, and it is only in this way that we can regard enumerations like the oft-repeated lists, as, for instance, those by Humboldt, which tell us that there are only 225 active volcanos in the world.

As to what is a volcano, whether it is active, dormant, or extinct, and how volcanos are to be enumerated, are questions which require discussion, and upon which I hope to offer a few remarks in a contribution which I am preparing upon the volcanos of Japan.

In conclusion, I may remark, that through the kindness of Mr. Snow, I have obtained a few more specimens of rocks from the Kuriles. These are like those which I obtained before, namely, Andesites,—a class of rock which seems to be as characteristic of the Pacific area as Basalts are of the Atlantic. J. Milne.

Yedo, Japan, *Jan.* 11, 1880.

MISCELLANEOUS.

Geological Survey of Japan.—Reports of Progress for 1878 and 1879. By B. S. Lyman. Tokei, 1879. These reports give a short statement of the work carried on in the field during 1878 and part of 1879. Besides descriptions of the metalliferous deposits of gold, silver, and lead, attention was paid to the extent and yield of the coal-fields of Yesso; it appears that the productive coal-fields as at present ascertained occupy about 350 square miles. The chief aim, however, was to finish the survey of the oil lands of Japan, to complete the reconnaissance of the whole country that had already been begun, and to ascertain what places most needed detailed surveys. The reports are accompanied by a small map of the eastern part of Asia, to show the position of the productive coal-fields of Yesso, Japan, and geological and topographical maps of the Kayanoma, Nuppaomanai and Bibai coal-fields. Tables are also given of the principal facts in regard to the oil wells of Akita Ken; and of all Japan.—J. M.

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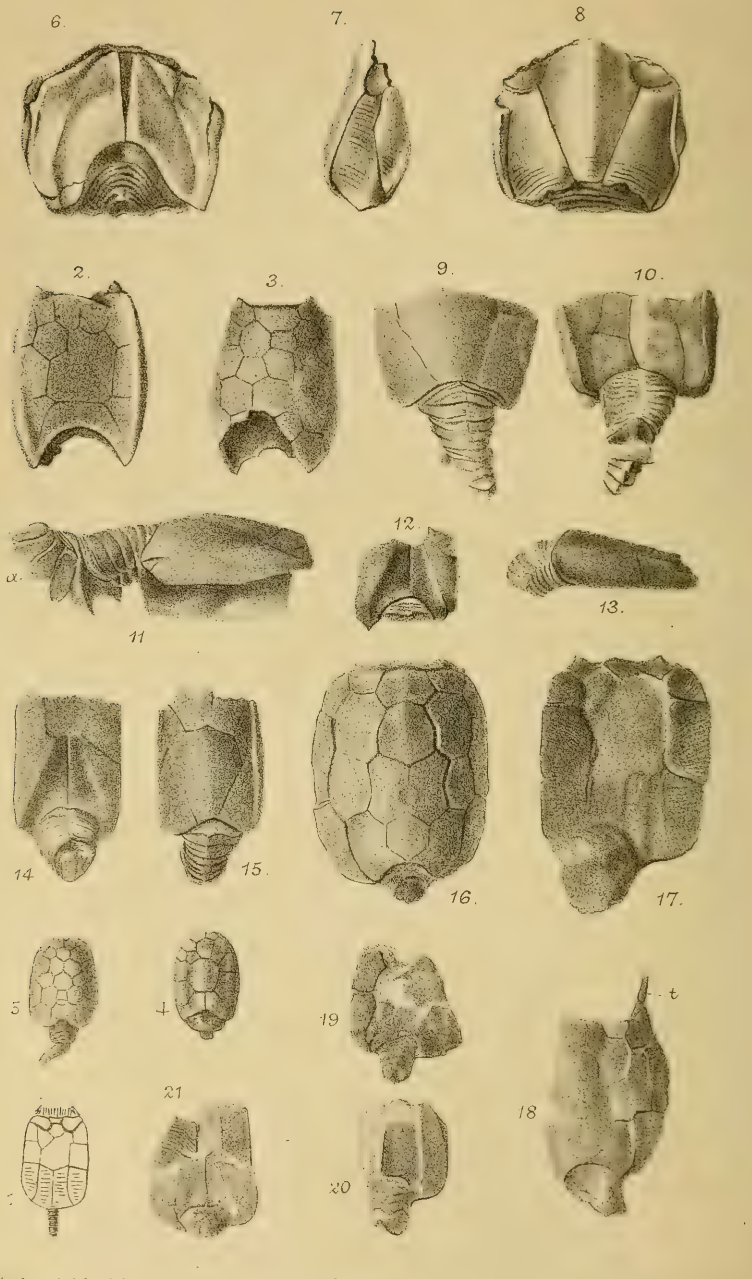

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No. V.—MAY, 1880.

ORIGINAL ARTICLES.

I.—Notes on the Anomalocystidæ, a Remarkable Family of Cystoidea, found in the Silurian Rocks of North America and Britain.

By Henry Woodward, LL.D., F.R.S., F.G.S.;
of the British Museum.

(PLATE VI.)

TWENTY-TWO years ago, Mr. E. Billings, F.G.S., the late excellent palæontologist to the Geological Survey of Canada, completed and published Decade iii. of his "Figures and Descriptions of Canadian Organic Remains" (Montreal, 1858), containing an admirable monograph on "the Cystideæ of the Lower Silurian Rocks of Canada," wherein (at pp. 72–74) he gives a clear and concise account of a very extraordinary fossil Cystidean, with a very poor woodcut figure of one side, the plates of which he clearly describes. To this fossil he gave the name of *Ateleocystites Huxleyi.* The specimen was obtained from the Trenton Limestone, near Ottawa, Canada. (See our Plate VI. Fig. 1.)

Following immediately upon this Canadian Memoir appeared, in 1859, the third volume of Prof. James Hall's magnificent work, the Palæontology of New York; wherein (at p. 132) he describes a new genus of Cystoidea, closely related to the above, under the name of *Anomalocystites.* Two species are described by Prof. Hall, namely, *A. cornutus* (*op. cit.* p. 133, pl. vii. A. figs. 5–7), from the Pentamerus Limestone, Lower Helderberg group, Litchfield, Herkimer Co., and *A. disparilis* (*op. cit.* p. 145, pl. lxxxviii. figs. 1–4), from the Oriskany Sandstone, Cumberland, Maryland. (Pl. VI. Figs. 2–5.)

In 1859 Prof. James Hall (Palæontology of New York, vol. iii. p. 132) thus described his genus *Anomalocystites*:

"Body semielliptical or semiovoid, sides unequal; the vertical outline oval or ovoid, plano-convex, or concavo-convex; the transverse outline semielliptical, the base of which is straight or more or less concave; the two sides composed of an unequal number of plates. Basal plates, three on the convex side, two on the concave side: second series, two large plates at the angles, and four (or five ?) on the convex side: third series, four on the convex side one at each angle, and a large plate on the concave side: a fourth, fifth, and sixth series of plates on the convex side, and a fourth series on the concave side. Base oblique, with the convex side longer, and a deep concavity for the insertion of the column.

Pectinated rhombs apparently none. Arms unknown. Column deeply inserted into the body, composed of large joints above, becoming smaller below."

In the Bulletin de l'Académie Royal, Bruxelles, 1869 (2nde série, tome xxviii. pp. 57–65, Planche), Prof. L. G. de Koninck, of Liège, gives descriptions of "some new and remarkable Echinoderms from the British Palæozoic Rocks." This paper, a translation of which I published, together with the original plate, in London (see GEOLOGICAL MAGAZINE, 1870, Vol. VII. pp. 258–263, Pl. VII.), gives, among others, a fairly accurate description (as far as could be made out from the specimen) of a new Cystidean from the Upper Silurian of Dudley, under the name of *Placocystites Forbesii*.[1]

I appended a note to this paper (on p. 261, GEOL. MAG. 1870), adding further details concerning this fossil, and I also then expressed my conviction that *Placocystites Forbesii*, De Kon., and *Ateleocystites Huxleyi*, Billings, would probably hereafter be shown to be the "anterior" and "posterior" surfaces of the same Cystidean.[2]

Having obtained a large series of *Placocystites Forbesii*, De Kon., from Dudley, I was enabled to make an accurate drawing of both the "dorsal" and "ventral" aspect of this anomalous fossil, which I forwarded, in 1870, by Sir W. E. Logan, to Mr. E. Billings in Montreal. His reply, together with my figures and remarks thereon, appeared in the GEOLOGICAL MAGAZINE for 1871 (Vol. VIII. pp. 71–72 and woodcut), which are reprinted herewith.

I subjoin a copy of the woodcut, and have drawn up a brief description of *Ateleocystites* (*Placocystites*) *Forbesii*, De Koninck, as it has never been heretofore fully described.

Order—CYSTOIDEA.

Family.—ANOMALOCYSTIDÆ.

Genus.—*Ateleocystites*, Billings, 1858.

Syn. *Anomalocystites*, Hall, 1859.
Placocystites, De Koninck, 1869.
? *Ateleocystites*, Meek, 1873.
Enoploura, Wetherby, 1879.

GENUS.—Body compressed in form, posterior side convex, anterior side concave, composed of about four series of plates, more numerous and more symmetrically disposed on the convex side, less numerous and somewhat less symmetrically disposed on the concave side. All the body-plates (with the exception of the ovarian plate) having a finely striated and wavy ornamentation, running in an obliquely-transverse direction across their surface.

The "anal" plate is placed on the central line on the *convex* side[3] of the body at the junction of two plates placed in juxtaposition and immediately above the "ovarian" plate. Arms *two* or more in number, pinnulæ small or absent? Base excavated for the insertion

[1] Only the *convex* side was examined and described by Prof. de Koninck; the concave side yielded no information to its learned investigator, being imperfect.

[2] In this it appears I was in error. Mr. Billings did not affirm them to be actually the same species, but only to belong to the same genus; I misread his note to me at the time. M. de Koninck's *species* should therefore be retained.

[3] Referred to by Billings as the "*ventral*" side.

of the column, which (as in *Glyptocystites, Pleurocystites,* and many others) was comparatively large at its attachment to the body, and was composed of narrow, somewhat compressed rings, to fit the flattened form of the base of the body. These rings appear to have diminished rapidly in size downwards, as in most other Cystideans.

SPECIES.—*Ateleocystites* (*Placocystites*) *Forbesii*, De Koninck, 1869.

——— ——— Bull. Acad. Roy. Bruxelles, 2nde série, tome xxviii. pp. 57–65, avec Planche.

——— ——— GEOL. MAG. 1870. Vol. VII. p. 260, Pl. VII. Figs. 2–5.

Ateleocystites (*Placocystites*) *Huxleyi*, H. Woodw. (*non* Billings), GEOL. MAG. 1871, p. 71.

——— ——— *Fletcheri*, Salter, Cat. Camb. et Sil. Foss. Woodw. Mus. Camb. 1872, p. 128.

General form of body oblong, compressed, especially at the lateral margins, which are sharply carinated; convex on the posterior side, concave on the anterior side; having the lower angles rounded and the base somewhat deeply emarginated to receive the column. The body on each side composed of three oblong carinated marginal plates, placed one above the other, forming a "radial series" (Hall; De Koninck). In addition to these, the posterior or convex side is covered by 13 small polygonal plates, and the anterior or concave side by 7 irregularly-shaped oblong plates, the three lower of which are by far the largest. The two lower marginal or 'radial' plates are longer than wide, and all three plates are so unequally folded over the sharply compressed lateral border as to give two-thirds of their breadth to cover the concave anterior side of the body, and only one-third to the convex posterior side. The lowest pair of carinated radial plates is strongly recurved, bending round the inferior margin of the body, and uniting with the small basal plates that encircle the articular surface for the column.

On the concave anterior side, between these lowest pair of marginal plates, are seen two symmetrical oblong plates, about twice as high as wide; slightly broader at their lower half, their outer margins curved, their inner or median ones quite straight, their lower borders emarginated to receive the column.

Resting upon the upper edges of these two plates is a single large oblong plate, the right-hand upper corner of which is truncated, giving insertion to a small and somewhat irregularly-shaped triangular plate; these plates are flanked by two large oblong marginal or radial plates, followed by two very much smaller ones resting upon them; these latter serve to complete the superior angles of the body, and give insertion to two arms or tentacles, at their upper edge. Three small plates, broader than deep, form the summit of the body on the concave or anterior side.

On the convex posterior side, the arrangement of the plates is perfectly symmetrical, including the borders of the marginal or radial plates. The base supports a horizontal series of three plates, a broad median hexagonal plate, bearing a little to one side, a small circular plate covering the 'ovarian' aperture. The two lateral plates, placed next to the median hexagonal plate, encircle that plate at its base and join with it to form the lower border of the body, and rest upon the two narrow 'basals' that encircle the attachment for the column. Above these is a second horizontal series of four plates, resting upon and alternating with the plates beneath. In this way the suture becomes median, and it is upon this suture, and towards the middle of the two centre plates, that the "anal plate" is situated; it is circular and about 3 mm. in diameter. The series which follows that inclosing the anal plate is only composed of three plates, a little longer than broad, alternating with those which serve as their supports, the median plate being the broadest. The summit is also composed of three small plates, of which, as in the preceding, the centre one is the largest.

The plates covering the body, with the exception of the small 'anal,' 'ovarian,' and 'basal plates,' are all similarly ornamented with fine raised wavy striæ running obliquely-transversely across their surface.[1] This well-marked ornamentation has been observed by E. Billings (Montreal), Prof. Jas. Hall (Albany, N.Y.), and F. B. Meek (Cincinnati), as characteristic of American species of Cystoidea belonging to this group.

In the Geological Magazine for 1871, Vol. VIII. pp. 71–72, I published a "Note on a New British Cystidean," with a woodcut giving figures of anterior and posterior side of *Ateleocystites* (*Placocystites*) *Forbesii*, De Koninck sp., together with a note by Mr. E. Billings, which I here reproduce:—

"Dear Sir,—Sir W. E. Logan gave me your sketch of *Placocystites*, and I have this morning re-examined all of our specimens, and also compared Prof. de Koninck's figures and descriptions in the article in the Geol. Mag. to which you refer. *Placocystites* and *Ateleocystites* are *undoubtedly* the same, as suggested by you.

"*Anomalocystites*, Hall (Pal. N.Y., vol. iii. p. 134, pl. 7A and 88), is also the same genus. The number of plates is different in the English, Canadian, and New York species, but this does not matter in such a genus of Cystideans as this. Since my Decade was published, we have collected several additional specimens of *A. Huxleyi*, but, unfortunately, none of them give any new information. They are all imbedded in the rock, and all show the same—the *concave* side. The four species—*Ateleocystites Huxleyi*, Billings, Lower Sil.; *Placocystites Forbesianus*, De Koninck, Upper Sil.; *Anomalocystites cornutus*, Hall, Upper Sil.; *Anomalocystites disparilis*, Hall, Devonian —are all composed of a limited number of plates not arranged in regular series, their bodies convex on one side and concave on the other. The first three have the plates transversely striated in a peculiar manner, and most probably good specimens of the fourth would show the same surface character. This striation is of the

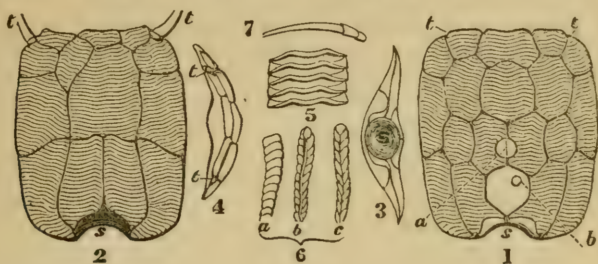
[1] I am only acquainted with one other organism from the Upper Silurian rocks which is similarly ornamented, namely, the plates of *Turrilepas*.

Future discoveries may possibly enable us to correlate this anomalous Cirripede (?) with our *Ateleocystites*, but at present we have not the evidence before us for doing so.

same kind in all, and differs in aspect from that of any other Cystidean genus known. It is so peculiar that it appears to be near a sort of a *group character*, so to speak, like the scale-markings of some of the Crustacea.[1] These points of agreement are of such a nature that, although none of the species have been as yet described on good specimens, they seem quite sufficient to prove that they are congeneric.

"*Montreal*, 1871. E. BILLINGS."

We subjoin figures of the anterior and posterior surfaces of this remarkable Cystidean, for the elucidation of which we now possess a very fine series of specimens, many of which have been collected by C. Ketley, Esq. The original of Fig. 1 was obtained by J. Gray, Esq. (All the above specimens are in the British Museum, and were obtained from the Wenlock Limestone, Wren's Nest, Dudley.)



Ateleocystites (*Placocystites*) *Forbesianus*, De Kon. sp.

FIG. 1. Posterior or convex side, showing the "anal plate" (*a*), and the ovarian plate (*b*), the base of the tentacles (*t*, *t*), and the point of attachment for the column (*s*).

,, 2. Anterior or concave side showing the tentacles (*t*, *t*).

,, 3. View of the lower extremity of the body, showing the surface for the attachment of the column (*s*).

,, 4. View of the top of the body, showing the points of attachment for the arms or tentacles (*t*, *t*).

,, 5. Portion of the column near the body: drawn from specimens having a portion of the column still remaining attached.

,, 6. *a*, *b*, *c*. Three views of a small tapering column found detached, but having the same characteristic sculpture visible upon its joints observed in *Ateleocystites*. Probably the lower extremity of the column.

,, 7. One of the arms, or tentacles, drawn from a specimen, having the arms still attached to the body.

No other form belonging to this anomalous group was recorded, until Mr. F. B. Meek described and figured in the Geological Survey of Ohio, 1873 (p. 41, pl. 3 bis, figs. 6, *a*, *b*, *c*), the fragmentary remains of a new species, evidently closely related to *Ateleocystites Huxleyi*, under the name of *Anomalocystites* (*Ateleocystites ?*) *balanoides*, Meek, the description of which we subjoin :—

[[1] "Compare the ornamentation of *Ateleocystites* with the plates of *Turrilepas Wrightii*, also from the Wenlock Shale and Limestone, Dudley [figured and described by H. Woodward, in the Quart. Journ. Geol. Soc. 1865, vol. xxi. pl. xiv. figs. 1*a* to 1*i*. See also GEOL. MAG. Vol. II. 1865, p. 470 (Woodcut)]. Can it be possible that any actual relationship exists between these two remarkable and aberrant forms ?—H.W." (GEOL. MAG. 1871, Vol. VIII. p. 72.)]

Anomalocystites (*Ateleocystites ?*) *balanoides*, Meek. Part ii. vol. i. Geol. Surv. Ohio, 1873, p. 41, pl. 3 bis, figs. 6, *a*, *b*, *c*.

"The only specimens of this fossil that I have seen are in a bad state of preservation, being distorted by pressure, and consisting only of the lower portions of the body, and some of the extremely thin segments of the thickened part of the column connecting with the base of the same. One side of the body was evidently flat, or a little concave, and the other convex; and the entire outline, as seen on either of these sides, was probably oblong-suboval; while the lateral margins are distinctly carinated, at least toward the lower part.

"The surface is finely and obscurely granulo-striated, these markings showing a tendency to run longitudinally on the marginal pieces, and transversely (but much interrupted and broken up) on the middle pieces of the flat side. On the convex side they generally assume more the character of obscure irregular granules, excepting near the lower ends of the two lateral of the three principal pieces, where they become a little more regularly arranged, rather distinct, raised transverse lines.

"The column was evidently comparatively very large at its connexion with the body, and composed of extremely thin pieces, that are not transverse, but (at least near the body) bent or deflected, so as to conform to the sinuous margins of the base of the body. It also seems probable that the habitual posture of the body, with relation to the column, was such that the two were not on a line with each other, but more or less flexed or bent, so that the column connected with the body obliquely, somewhat as in *Eucheirocrinus* (*Cheirocrinus*, Hall, 1860; not Eichwald, 1856). At least the much deeper sinus for the connexion of the column, in the lower range of pieces on the flat side, than on the convex, would favour such conclusion.

"Length of body unknown, but it measures 0·93 inch in breadth, and about 0·40 inch in convexity, near the lower part; breadth of upper end of column, about 0·49 inch.

"Although this species is evidently closely allied to the genera *Anomalocystites* and *Ateleocystites*, I am not positively sure that it would be found exactly congeneric with either, if we had the means of comparing its entire structure with that of the types of these groups, which are very closely related to each other. It certainly differs conspicuously, at least in its specific characters, from the typical and only known forms of these groups. In the first place, it is much larger than *Anomalocystites cornutus*, and has the middle two pieces of its lower range on the flat side proportionally longer—that is, longer than the marginal pieces, instead of the reverse. Its base is also more deeply sinuous on this side than in the New York species. On comparing its convex side with that of *A. cornutus*, we observe still more marked differences; the three principal plates of the lower range in our type being all decidedly longer than wide, instead of the reverse, and the middle plate considerably longer than that on each side of it; while the carinate marginal pieces, which are quite distinctly seen in this view of our species, are scarcely visible on this side of the New York species. There are doubtless also equally great differences in the arrangement and structure of the parts above on both sides, if we had the means of making comparisons of this part of the body.

"In size, our species corresponds more nearly with *A. disparilis* from the New York Oriskany Sandstone; but from what has already been stated, it will be seen to differ too widely in the form and proportions of its lower range of plates to render a comparison necessary.

"Compared with *Ateleocystites Huxleyi* of Billings, the type and only known species of that group (if it is distinct from *Anomalocystites*), our species will be found not only to differ in its much larger size, but also in having its base greatly more widely and deeply sinuous on the flat side, for the reception of the column; while its central two pieces taper more rapidly upwards, and are longer in proportion to the lateral ones. Its lateral pieces, on the contrary, taper more decidedly downward, and differ in having their lower ends curved inwards. The convex side of *A. Huxleyi*, and the upper parts of our species being unknown, we have no means of carrying the comparison farther, but enough can be seen to show, beyond doubt, that the two forms are at least clearly distinct specifically.

"*Locality and Position:*—Upper part of the hills at Cincinnati, Ohio, in the Cincinnati group of the Lower Silurian."

Although Mr. Meek was apparently unaware of the more perfect remains of this genus afforded by our English Wenlock Limestone, he had no doubt of the proper order to which to refer the fossil under consideration, and, like Mr. Billings, he had evidently been struck with the well-marked family character which these genera of Cystideans display. His closing remarks thoroughly bear out the opinion expressed in Mr. Billings's note already quoted. Mr. Meek writes:—

"Whether these several types belong to one, two, or three genera, it must be evident, I think, to any one accustomed to study these old types of the Echinodermata, that in a systematic classification or arrangement of the genera of the CYSTOIDEA into families, they will have to stand together in a distinct family, ANOMALOCYSTIDÆ, occupying a somewhat analogous position in this group to that of the family including *Eucheirocrinus* of the Crinoidea."

As it seems proper, according to the law of priority, that the genus *Anomalocystites* of Prof. James Hall (1859) should be included under that of *Ateleocystites* of Billings (1858), I venture to second the proposal of the late Mr. F. B. Meek (whose opinion, as a profound and accomplished palæontologist, few would venture to gainsay) that these remarkable forms—whether placed under one genus (*Ateleocystites*) or more than one—should be arranged in a distinct family under the name:—

Fam.: ANOMALOCYSTIDÆ, F. B. Meek, 1873.

Ateleocystites Huxleyi, Billings, 1858. Fig. and Descrip. Canadian Organic Rem. Montreal, Geol. Surv. Canada, decade iii. p. 72.

——— (*Anomalocystites*) *cornutus*, Hall, 1859. Palæontology New York, vol. iii. pp. 132–133, pl. vii*a*. figs. 5–7.

——— (———) *disparilis*, Hall, 1859. Op. cit. p. 145, pl. lxxxviii. figs. 1–4.

——— (*Placocystites*) *Forbesianus*, De Koninck, 1869, Bull. Acad. Roy. Bruxelles, 2e série, t. xxviii. pp. 57–65, plate; and 1870, GEOL. MAG. Vol. VII. p. 260, Pl. VII. Figs. 2-5.

———, ——— ——— GEOL. MAG. 1871, p. 71 and Woodcut (giving accurate figures of both sides).

——— (*Anomalocystites*) *balanoides*, Meek, 1873. Geol. Surv. Ohio, part ii. vol. i. p. 41, pl. 3 bis, figs. 6, *a*, *b*, *c*.

Note in conclusion.—In the Journal of the Cincinnati Society of Natural History, vol. i. No. 4, January, 1879, p. 162, Prof. A. G. Wetherby gives a "Description of a New Family and Genus of Lower Silurian *Crustacea*," which he names *Enoploura balanoides*. This is in fact a redescription of the same species of Cystidean from the Lower Silurian of Cincinnati referred in 1873 by Prof. F. B. Meek to the genus *Anomalocystites*.

Mr. F. B. Meek was fully aware of the fragmentary nature of the fossil he was describing, but his diagnosis of its characters was such as might well be expected from so able and experienced a palæontologist, and one so thoroughly acquainted with Invertebrate fossil organic remains.

It was with no little surprise therefore that I found, upon perusing Mr. Wetherby's description, that he was dealing with a fragment of a Cystidean belonging to a genus which was carefully studied and described twenty-two years ago by Billings and Hall, and ten years ago by De Koninck. Yet Prof. Wetherby, whilst apparently unaware of the literature of the subject, and equally unacquainted it would seem with this anomalous group of Cystideans, has essayed to upset the diagnosis of a fragmentary fossil accurately determined by so eminent an authority as Prof. Meek, and has relegated it, on almost equally fragmentary evidence, to the class Crustacea, an error which his knowledge of the characters of that class should have prevented him from falling into.[1]

Prof. F. B. Meek had evidently been struck with the peculiar Cirripedal-like sculpturing on the plates of *Ateleocystites*, and hence was led to give his species the trivial name of *balanoides*. I had also remarked (GEOL. MAG. Vol. VIII. 1871, p. 72), "Compare the ornamentation of *Ateleocystites* with the plates of *Turrilepas*" (Quart. Journ. Geol. Soc. 1865, vol. xxi. pl. xiv. p. 486), the only other Silurian fossil which has this peculiar ornamentation of delicate wavy lines of elevated striæ; but there the analogy ends. Every point about *Ateleocystites* agrees with the known characters of this singular Cystidean family, and no one who has studied them attentively can doubt the propriety of the determinations of MM. James Hall, E. Billings, De Koninck, and F. B. Meek, as

[1] See Note by C. Stewart, Esq., F.L.S., Sec. R.M.S., on the microscopic structure of *Ateleocystites*, etc., at p. 240, unfortunately received too late for insertion here.—EDIT. GEOL. MAG.

regards the zoological position in which they should be placed. Professors James Hall, De Koninck, and myself have had the good fortune to see and study more perfect specimens than those which were placed in the hands of Messrs. Meek and Billings, but it is all the greater honour to these latter savans that they rightly interpreted the fragmentary remains which came under their notice for description.

I am the last person who would insist merely upon the dictum of recognized scientific authority, and I beg to assure Prof. Wetherby (whom I have not the pleasure personally to know) that I have no desire to detract from his work by any word of mine; but I may be permitted to suggest that hasty publication, with a view to obtaining "priority," may have caused him in this instance to overlook the importance of first becoming thoroughly acquainted with the subject before him. None but those who have to spend their lives in scientific research know the piles of "chaff" which every careful worker has to winnow away before he can arrive at the substratum of really good "grain" beneath.

If Prof. Wetherby desires his work to stand, he must be prepared not only to hunt up carefully the bibliography of his subject, but also to understand more thoroughly the class characters of these difficult Palæozoic forms before attempting, on very imperfect materials, to correct older and more experienced labourers in palæontology.

EXPLANATION OF PLATE VI.

Ateleocystites, Billings (1858), = *Anomalocystites*, Hall (1859).

Fig. 1. *Ateleocystites Huxleyi*, Billings, Trenton Limestone, U. Silurian, Hull, near Ottawa, Canada. (Copied from E. Billings' woodcut, p. 73, Decade iii. Geol. Surv. Canada, 1858.)

,, 2 and 3. *Ateleocystites (Anomalocystites) disparilis*, Hall, 1859, Oriskany Sandstone, U. Silurian, Cumberland, Maryland, U.S.A.

,, 2. Anterior, concave side. Fig. 3. Posterior, convex side (after Hall's Palæontology, New York, 1859, p. 145, pl. lxxxviii. figs. 1 and 2).

,, 4 and 5. *Ateleocystites (Anomalocystites) cornutus*, Hall, 1859, Pentamerus Limestone, L. Helderberg group, U. Silurian, Litchfield, Herkimer Co., U.S.A.

,, 4. Anterior, concave side. Fig. 5. Posterior, convex side (after Hall's Palæontology, New York, 1859, p. 133, pl. viiA. figs. 5 and 6).

,, 6, 7, 8. *Ateleocystites (Anomalocystites) balanoides*, Meek, 1873, Cincinnati group, Lower Silurian, Cincinnati, Ohio, U.S.A.

,, 6. Anterior, concave side. Fig. 8. Posterior, convex side (after Meek's Geol. Surv. Ohio, 1873, pl. 3 bis, figs. 6*a.b.c.*).

,, 9–15. Ditto (*Enoploura balanoides*), Wetherby, 1879, Journ. Cincinnati Soc. Nat. Hist. vol. ii. No. 4, p. 162, pl. 7, figs. 1, and 1*a–g*.

,, 9, 11,* 13, 15. Posterior, convex side. Fig. 10, 12, 14. Anterior, concave side. *Loc.* Cincinnati, Ohio.

,, 16–21. *Ateleocystites (Placocystites) Forbesianus*, De Koninck, 1870, Wenlock Limestone, U. Silurian, Dudley.

,, 16. Posterior, convex side. Fig. 17–21. Anterior, concave sides. Fig. 18*t*. tentacle.

Figs. 16-21 are drawn from the original specimens preserved in the British Museum (all natural size).

*[Is it possible that the associated plates *a*. fig. 11, which Prof. Wetherby considers to be "abdominal appendages," are the plates of *Turrilepas*? If this were the case, and their association not merely fortuitous, it might prove, not that *Ateleocystites* was a Crustacean, but that *Turrilepas* was possibly the peduncle of this anomalous Cystidean! We commend this point to Prof. Wetherby's consideration.]

II.—Notes on the History and Comparative Anatomy of the Extinct Carnivora.

By P. N. Bose, B.Sc. (Lond.), F.G.S.

I.—Eocene Period.

§ 1. *Introduction—Historical and Bibliographical.*

At the beginning of this century nothing whatever was known about the history of the Carnivora in the Eocene period. In 1825, in the second edition of his "Recherches sur les Ossements fossiles," Cuvier described certain fossil bones from the Gypseous Series as belonging to a Carnivore allied to the Racoons and the Coatis.[1] Ten years afterwards,[2] having obtained a palate from the same beds, furnished with five teeth on one side and four on the other, he referred the palate, as well as the bones alluded to above, to a genus allied to *Didelphis*. De Blainville, in his "Osteographie," founded on these bones a genus allied to the Badger, which he placed amongst the "Petits Ours" (*Subursidæ*), under the title of *Taxotherium*,[3] while he referred the supposed Didelphoid teeth of Cuvier to a distinct genus, *Pterodon*,[4] to which also he assigned a place in the same group.

The establishment of a novel and highly interesting genus in 1838,[5] by Laizer and Parieu, on a lower jaw from certain deposits of the Inferior Miocene age, marked an epoch in the history of the Carnivora. It was in a happy moment—unhappy, no doubt, for *Hyenodon*—that this creature was disturbed from the repose it had enjoyed for so many ages. Its discoverers associated it with the Thylacine and the Dasyure. But De Blainville refuted their arguments,[6] and in his "Osteographie," the *Hyenodon leptorhynchus* of Laizer and Parieu was placed in the group of the *Canidæ*.[7] The discovery of more perfect specimens of *Hyenodon* by M. Felix Dujardin opened afresh the question of its affinities. Dujardin reverted to the original hypothesis of Laizer and Parieu; and he was supported by Pomel.[8] De Blainville was so far influenced by the discovery of Dujardin as to make room for *Hyenodon* in his group of the "Petits Ours"; but at the same time he added a note of interrogation after it, expressing, no doubt, his suspicion as to its generic identity.[9] Laurillard[10] and Pictet[11] incorporated the *Taxotherium* and *Pterodon* of De Blainville with *Hyenodon*. But the accomplished writer in the Dictionary of Natural History decided in favour of the Marsupial affinities of this genus. Pictet, however, maintained its

[1] *op. cit.* t. iii. p. 271.
[2] "Rech. sur les Ossem. foss." 4th edit. t. v. p. 490.
[3] *op. cit.* gen Subursus, p. 55, pl. xii.
[4] *op. cit.* gen. Subursus, p. 48, pl. xii.
[5] "Comptes rendus de l'Acad. des Sc." 1838, 2e sér. p. 442.
[6] "Comptes rendus de l'Acad. des Sc." 1838, 2e sér. p. 1004.
[7] *op. cit.* gen. Canis, p. 111.
[8] Bull. Soc. Geol. de Fr. 2e sér. t. 1, p. 591; t. v. p. 385.
[9] "Osteographie," gen. Subursus, p. 102, pl. xvii. Subsequently *H. brachyrhynchus* was transferred to the Canidæ, "Ost." Canis, p. 113.
[10] "Dict. d'Hist. Nat." t. vi. p. 767.
[11] "Traité de Pal." t. i. p. 196.

relationship with the Placental Carnivora, and placed it provisionally amongst the *Ursidæ,* by the side of *Amphicyon* and *Arctocyon.* M. Paul Gervais united De Blainville's *Taxotherium* with *Hyenodon,* but maintained the generic distinctness of *Pterodon.*[1] Later discoveries have proved the soundness of Gervais' opinion; and these two genera have ever since remained distinct. Gervais threw the weight of his authority on the side of De Blainville as to their zoological position; but placed them amongst the Felidæ in the second edition of his "Zoologie et Palæonotologie Française." Lately, MM. G. Vasseur[2] and H. Filhol[3] have adduced very strong evidence in favour of retaining *Hyenodon* in the company of the Placental Carnivora. Later still, however, Prof. Gaudry[4] has carried it back to the place originally assigned it by Laizer and Parieu. So that ever since *Hyenodon* was unearthed, it has had to lead a most restless existence. We hope to be able to assign it and its companion, *Pterodon,* a place where they would be allowed to rest unmolested.

If *Hyenodon* and *Pterodon* deserve credit for having given rise to such a long controversy, and caused such a division amongst the able palæontologists mentioned above, *Arctocyon* enjoys the unique reputation of being the most primitive mammal known to us since the conclusion of the Mesozoic epoch. Its remains have been found in deposits of the same age as the "Thanet Sands" of this country. De Blainville, who first introduced it to the palæontological world, found it a place amongst the "Petits Ours."[5] Laurillard, however, transferred it to the group of the *Didelphidæ.*[6] Prof. Gervais seems rather to have inclined to the same view. But, by way of compromise, he more lately proposed to establish a separate family under the title of the *Arctocyonidæ* for its reception.[7] Quite recently, however, M. Albert Gaudry has decided to class it with the Marsupials.[8]

Palæonictis, too, based by De Blainville on a lower jaw from beds of the same age as the Woolwich and Reading of this country, and associated with the Civettes by him, has shared the fate of *Arctocyon* at the hands of the learned Professor of Palæontology at the Natural History Museum of Paris.[9] The genera *Cynodon* and *Elocyon* were established by Aymard on certain remains from deposits of the Inferior Miocene Age, in 1849.[10] The same palæontologist based a genus called *Cyotherium* on the *Viverra Parisiensis* of Cuvier,[11] and the *Canis viverroides*[12] of De Blainville, both from the Gypseous series of Paris. A year afterwards Bravard and Pomel described certain remains from deposits of the same age under the name of

[1] "Zool. et Pal." 2e edit. p. 236.
[2] "Compt. Rend." t. lxxvii. p. 1446.
[3] "Rech. sur les Phosph. du Quercy," Paris, 1877.
[4] "Les Enchaînements du Monde Animal," Paris, 1878.
[5] "Osteographie," gen. Subursus, p. 73, pl. xiii.
[6] "Dict. d'Hist. Nat." t. ix. p. 400.
[7] "Nov. Archives du Mus. d'Hist. Nat. de Paris," t. vi. 1870, p. 147.
[8] *op. cit.* p. 23. [9] *op. cit.* p. 19.
[10] "Ann. de la Soc. d'Agr. du Puy," t. xiv. May, 1849.
[11] "Rech. sur les Ossem. foss." 4e edit. t. v. p. 496.
[12] *op. cit.* "Chiens," p. 109.

Cynodictis.[1] *Elocyon, Cyotherium,* and *Cynodictis* have been affiliated by some palæontologists with *Cynodon,* thus bringing back the date of the appearance of this genus to the Upper Eocene. Pictet has referred some fossils from the "Siderolithiques" of Mauremont to the *Amphicyon* of Lartet (a characteristically Miocene genus), and the *Cynodon* of Aymard.[2] The age of these beds is somewhat uncertain. But they are generally correlated with the Barton clays of this country, and the "Gres de Beauchamp" of France. The appearance of *Amphicyon* and *Cynodon* would, in that case, be coeval with the deposition of the lowest beds of the Upper Eocene or the Oligocene of some geologists. Though supposed by Prof. Gaudry to retain traces of their Marsupial ancestry, the location of both these genera in the order of the Placental Carnivora has never been questioned.

Some superb specimens are described by M. H. Filhol in his elaborate work[3] on the palæontology of the Phosphatic beds of Quercy under the title of "*Cynohyænodon,*" but they are not generically distinct from *Proviverra* (Rütimeyer) of certain Swiss "Siderolithique" deposits which have been placed by some geologists on the same horizon as the Bracklesham Series. They have too strong a resemblance, however, in their dentition to *Hyænodon* and *Pterodon* to be dissociated from these, and have accordingly been located with them amongst the *Didelphidæ* by Prof. Gaudry.

The only other Eocene genera of the Old World which have ever been referred to the Carnivora are the *Tylodon* and *Galethylax* of Gervais.[4] They are both very imperfectly known.

Within the last eight or nine years a flood of light has been thrown on the history of the Carnivora by the remarkable discoveries in America. In 1870, Dr. Leidy described a peculiar Carnivore from the Bridger Eocene under the designation of *Patriofelis.*[5] Two years later he described two other forms, *Sinopa* and *Uintacyon,* the former supposed by Dr. Leidy to be intermediate between *Canis* and *Hyenodon,* and the latter "a carnivorous animal probably marsupial." These three genera, comprising five species, have been re-described with plates in the Report of the United States Geological Survey of the Territories.[6] But the specimens on which they are based are very imperfect. Prof. Cope was more fortunate with his *Mesonyx* and *Synoplotherium,* both from the Eocene of Wyoming, and both presenting some points of resemblance to *Hyenodon.*[7] Hardly three years had expired since these two most remarkable forms of Carnivorous animal were brought to the notice of the scientific world, when Prof. Cope described several highly interesting Carnivores from the Lower Eocene (Wahsatch formation) of New Mexico.[8] He

[1] "Notice sur les Ossem. foss. de la Debruge," p. 5.

[2] "Memoire sur les Animaux Vertébrés trouvés dans le Terrain Sidérolithique du Canton de Vaud," pp, 73, 75, Pal. Suisse, 5e sér. pp. 134, 137.

[3] "Recherches sur les Phosphorites du Quercy," Paris, 1877.

[4] "Zool. et Pal. Française," 2e ed. pp. 219 and 225.

[5] Proc. Ac. of Sc. Philad. 1870, p. 10.

[6] *op. cit.* vol. i. pp. 114–118; pls. ii. vi. and xxvii.

[7] Proc. Amer. Philos. Soc. for 1872, pp. 460, 483; Ann. Rep. of the U.S. G. S. of the Terrs. for 1872, pp. 550, 554.

[8] Suppl. Cat. of the Vert. of the Eocene of N. Mexico collected in 1874.

was struck by their departure from the typical Carnivora and their approximation to the *Insectivora.* "It is indeed questionable," he says, "whether some of the genera here included as Carnivora are not gigantic Insectivora."

At a meeting of the Philadelphia Academy of Natural Sciences in 1875, Prof. Cope read a highly interesting paper on the classification of the Eocene Carnivora. In that paper he established a suborder of the Insectivora under the title of the *Creodonta*, for the reception of the Wahsatch genera, *Amblyctonus*, *Oxyæna*, *Stypolophus*, and *Didymictis*.[1] In the following year he changed the name of the order from Insectivora to *Bunotheria.* Full descriptions of the genera just mentioned have been recently published in a beautifully illustrated volume[2]—one of the most valuable contributions to our knowledge of the Eocene Mammals.[3]

Almost simultaneously with Prof. Cope, Prof. Huxley was struck with the Insectivorous affinities of the Eocene Carnivora found on this side of the Atlantic. In his highly suggestive and most comprehensive Lectures on Biology, delivered at the Royal School of Mines, he noticed the remarkable fact that the flesh-eaters of the Eocene period, so far as they depart from the typical Carnivora, approach the Placental Insectivora. Instead of having recourse to a hypothetical *Bunotherium* (as Prof. Cope does), Prof. Huxley pointed out how, by starting with the *Gymnura* as the central form in the group of the Insectivora, we could arrive at the dentition of the other orders of the Mammalia.

We propose first to consider the chief features in the dental conformation of the genera mentioned above; we shall then consider their osteology and the structure of their brain; and finally, in the last section, we shall discuss their affinities and their relations amongst themselves as well as to the other Carnivora.

The following table gives the stratigraphical distribution of the Eocene Carnivora. With regard to the Eocene of America, I have followed the correlation proposed by Prof. Cope, who regards the Wahsatch formation as Lower Eocene, and the Bridger as Middle Eocene.[4] I have incorporated the *Stypolophus* (Cope = *Prototomus*, Cope) with the *Proviverra* of Rütimeyer, for reasons which will be explained in the following sections. The genus *Didymictis* too should probably be affiliated with the *Palæonictis* of De Blainville.

[1] Proc. Philad. Ac. of Nat. Sc. for 1875, p. 444.

[2] Report of the U. S. Geographical Surveys, West of the 100th Meridian, part ii. vol. iv. Washington, 1877.

[3] Prof. Marsh described some very interesting remains of Carnivora from the Wyoming Tertiary in the American Journal of Science and Arts (3rd series, vol. iv. pp. 126, 202), under the names *Limnocyon*, *Viverravus*, *Limnofelis*, *Thinocyon*, *Thinolestes*, and *Telmalestes*. But the descriptions are very brief, and are unaccompanied by figures. I am not, therefore, in a position to notice them in the present paper. The remarkable group of the *Tilladontia* established by Prof. Marsh, which combines the characters of the Ungulates, Rodents, and Carnivores, will be noticed in the last section.

[4] Proc. Ac. Nat. Sc. Philad. 1876, p. 63.

European Genera.	Thanet Sands (E). Sables de Bracheux (F).	Woolwich and Reading (E). Lignites du Soissonais (F).	London Clay (E). Argile de Londres (F).	Alum Bay and Bournemouth Beds (E).	Bracklesham Series (E). Calcaire Grossier (F). Dépots Sidérolithiques d'Obergösgen et d'Egenheigen (S).	Barton Clays (E). Grés de Beauchamp (F). Dépots Sidérolithiques du Mauremont (S).	Headon and St. Helen's Series (E.) Calcaire Siliceux (F).	Bembridge Series (E). Gypse de Paris: Couches de la Debruge (F).
Arctocyon (De Blainv.)	*primævus* (S.)							
Palæonictis (De Blainv.)	.....	*gigantea* (F.)						
Proviverra (Rütim.)	.....	.....	.....	.....	*typica* (S.)			
Pterodon (De Blainv.)	.....	.....	.....	.....	*dasyuroides* (S.)	.....	.....	(M.) *dasyuroides* (F.)
Amphicyon (Lartet)	.....	.....	.....	.....	.....	*helveticus* (S.)		(M.)
Cynodon (Aymard)	.....	.....	.....	.....	.....	*helveticus* (S.)		*lacustris* (F.) (M.) *parisiensis* (F.)
Hyenodon (Laiz. et Par.)	.....	.....	.....	.....	.....	*sp.* (E.)		*Requieni* (F.) (M.) *parisiensis* (F.)
Galethylax (?) (Gerv.)	.....	.....	.....	.....	.....	.....	.....	*Blainvillei* (F.)
Tylodon (?) (Gerv.)	.....	.....	.....	.....	.....	.....	.....	*Hombresii* (F.)

N.B.—E. = English; F. = French; S. = Swiss. Those genera which pass into the Miocene Period are indicated by an (M.) in the last column.

American Genera.	Lower Eocene. (Wahsatch).	Middle Eocene. (Bridger).
Proviverra (= *Stypolophus*, Cope) = *Prototomus*, Cope	5	3
Ambloctonus, Cope	1	.....
Oxyæna, Cope	3	.....
Palæonictis (= *Didymictis*, Cope)	1	.....
Patriofelis, Leidy	.....	1
Sinopa, Leidy	.....	2
Uintacyon, Leidy (= *Miacis*, Cope)	.....	2
Limnocyon, Marsh	.....	3
Viverravus, do.	.....	1
Limnofelis, do.	.....	2
Thinocyon, do.	.....	1
Thinolestes, do.	.....	1
Telmalestes, do.	.....	1
Mesonyx, Cope	.....	1
Synoplotherium, Cope	.....	1

N.B.—The numerals indicate the number of species.

§ 2. *Dentition.*

The teeth of all the Eocene flesh-eaters mentioned in the first section, as compared with those of the typical Carnivora, are apparently more or less anomalous. There is, as a very general rule, nothing exceptional in the form or number of the incisors or the canines. But the peculiarity in the arrangement, number, and form of the molar teeth, both upper and lower, has been the great stumbling-block in the way of comparative anatomists, some of whom, as we have seen, have tried to cut the Gordian knot by removing the majority of them to the group of the Didelphia. Amongst those who argue in favour of their location in the order of the Carnivora, the diversity of opinion with regard to the exact position they should occupy in that order shows the difficulty of affiliating them with any of the existing families. As we shall try to establish in this section that the peculiarities in the dentition of the Eocene Carnivores can be most satisfactorily explained on the hypothesis of its gradual modification from that of some primitive Mammal, the nearest approach to which is the Insectivorous *Gymnura*, now living in the islands of Malacca and Sumatra, we shall begin with a brief notice of the salient points in the dental conformation of this most generalized Mammal known to us.

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

III.—Woodwardian Laboratory Notes.—North Wales Rocks.

By E. B. Tawney, M.A., F.G.S.,

Woodwardian Museum, Cambridge.

In the following notes we propose to collect descriptions of some of the igneous rocks of N. Wales founded on the collections made by the late Prof. Sedgwick many years ago. It is hoped that it may be of interest to readers of this Magazine, as many students turning their attention to rocks find a want of information in text-books concerning precise localities in Britain for the occurrence of many interesting types. Following Sedgwick's steps may help them partly to what they require, while the microscopical analyses appended will doubtless prove an aid to beginners, besides being a definite record, as far as it goes, of some types of Welsh rocks.

In the Woodwardian Museum are deposited rich collections made by Sedgwick in travels through N. Wales, chiefly from 1831-6, illustrating not only the sedimentary formations, but containing a copious selection of the igneous rocks—made, too, at a time before there was any Geological Survey Map to act as a guide to localities where things of interest might be expected. These were all numbered by him according to the district where they were collected, and from his Catalogue we obtain the locality, as far as the imperfect topographical map with which he worked allowed it to be indicated, for the Ordnance Map was not then published. [The numbers in brackets will be those of his Catalalogue, and they are given to distinguish his from later additions.]

Owing to recent advances in Petrology due to the microscope, these full and carefully made collections have acquired fresh interest, while at the same time they required some further study. For arrangement purposes, and to adapt their names to the modern classification, it became desirable to slice and investigate some of them microscopically.

As the collections are due to travels also in Cornwall, the Lakes, Cheviots, etc., as well as N. Wales, there is an abundant store for future investigation. Choice was made, however, of N. Wales to begin with, as only due to the memory of the founder of the Cambrian System, and it is convenient to take first that N.W. less-explored part of it known as the Lleyn Promontory.

Prof. Bonney was good enough to make the first selections for slicing, and he distributed them among a few Cambridge students for investigation.[1]

Among the first so treated was one which at once attracted Prof. Bonney's attention and of which he furnishes the following description: [P. 85]

In this slide olivine, usually in rather rounded grains, is abundant. It is traversed by strings of serpentine, and is sometimes to a great extent converted into that mineral, with the usual grains and clotted granules of magnetite. Hornblende is also plentiful; it is strongly dichroic, changing from pale yellow-brown to rich clove-brown as the polarizer is rotated. There is some augite nearly colourless in thin sections; also a pale-greenish mineral, which occurs in radiated nests, tufted groups of fibres, and associated plates, like a mica. This last mineral is strongly dichroic, changing from a pale dull green to a pale golden-brown, and with ordinary light shows similar but fainter tints, the former when regarded perpendicular to the latter when parallel with the principal cleavage planes. Associated with it are specks, rods, and clotted bands of opacite. It is probably in part undecomposed brown mica, in part a species of chlorite (? ripidolite). The latter appears to be of secondary origin, and to result in part from the alteration of augite or diallage. The grains of olivine are frequently inclosed in the hornblende and sometimes in the augite.—T. G. B.

To a knowledge of the nature of the rock, it became desirable to add something of its occurrence, since the Geological Survey Map shows Penarfynydd as the sea termination of a long mass of greenstone extending N. and S. for some four miles—a mass which has been lately touched upon by Dr. Hicks [Q.J.G.S. vol. xxxv. p. 300] as containing gabbros intrusive in his Dimetian as well as in Silurian (Hicks).

Accordingly, last summer I made an excursion from Pwllheli, stopping a couple of days at Aberdaron for the sake of investigating the matter, (and also of searching for a particular rock in the Sedgwick Collection presumed to be from the Aberdaron Promontory, the extreme end of Lleyn).

Examining that end of the mass which extends from Plas Rhiw

[1] The initials of contributors will be appended to their communications.

to the S. end of the Penarfynydd Promontory at Trwyn Talfarach—indicated as Greenstone on the Survey Map—I found at least two distinct varieties of rocks: the blacker one I imagined to be the one I was seeking; but on comparing it with the slide described by Prof. Bonney, it is seen to differ, as he points out, by the greater abundance of olivine and the absence of felspar. Hence the question whether it has a separate existence or its relations to the rocks described below must be left to future investigation.

First, round Plas Rhiw and Treheli, where worked for "sets," it is a gabbro-like rock of medium grain. This continues through the ridge of Mynydd y Graig, not varying much locally with one exception. If one classed it by the outward appearance, it would probably be called gabbro from its brown colour, in contrast with the pronounced green colour of most of the diabases of the district. Microscopical examination shows, however, that the pyroxene has not well developed pinacoidal cleavage as typical diallage should have. To be logical we must therefore place it with the diabases. The second rock is very similar in appearance to that collected by Sedgwick from "below Penarfynydd," but which we were not fortunate enough to identify *in sitû*. It is an olivine-diabase, and holds over one side of Mynydd Penarfynydd ridge, being of sufficiently different appearance to the diabase, which forms the other half of this promontory.

It will be well first to describe its position with more detail. Mynydd Penarfynydd is a ridge about three-quarters of a mile long, running N.N.E.—S.S.W., coloured Greenstone on the Geological Map and connected with the rest of the greenstone mass by a narrow link. This connexion is of diabase, the extreme end of the promontory on the S. is also of the same diabase, as is also apparently the whole E. face of the ridge. Roughly speaking, the blacker or serpentinous olivine-diabase forms the W. slopes of the ridge from the crest downwards. It is seemingly then bounded by the diabase on two sides in such a way as to suggest that one is intruded into the other. As the ridge is covered by turf and heather, it is only possible to trace the line of junction by the blocks which occasionally protrude from the soil, many of which seem detached, but the line probably corresponds with the crest of the ridge.

In places where the olivine-diabase crops out it has a most delusive resemblance to a bedded rock—harder bands standing out with depressions between—the strike of these bands being N. 20° E., and dip at a moderate angle. On the W. slopes of the ridge this is very well seen also, little cliffs of olivine-diabase there weathering into apparent thick and thin beds, with planes of coarser and finer crystals, or harder and softer bands, which produce the effect of a weathering sedimentary series.

At the time I was disposed to think that the olivine-diabase had come up obliquely as a thick dyke inclosed between the diabase on the one side and the fossiliferous beds on the other, and that the harder and softer planes were parallel to the supposed inclined walls; but the case can scarcely be considered apart from others which show stratiform planes in gabbros, etc., and I must relinquish at present any attempt at explanation.

On the shore were loose blocks, one of which showed junction of the blacker olivine-diabase with the felspathic white-speckled diabase. I searched the ridge for a junction in place, and on the crest at one point was apparently a thick band of olivine rock lying on the lighter-coloured diabase ; I imagine this to be an oblique dyke inclosed in the other diabase, it had the same low angle of underlie as have the planes of the main mass of olivine-diabase. A subsidiary dyke might furnish proof of the relative ages of the two rocks—but in this case sufficient evidence was not found.

The W. slopes of the ridge, where they come down to the shore, are covered with drift, cliffs of mud and transported blocks, except near the extreme point of the promontory washed by the sea, to which the state of the tide prevented access on foot, while the turbulence of the weather was against boating from Aberdaron. I fear the junction is covered up; it is possible, however, that there may be dykes in the end of the promontory or in the cliffs of the E. side, which might settle the relative age.

Apart from lithological differences between the olivine- and other diabase,—one being greenish-black, the other brownish-grey spotted with white,—their appearance in the mass is by no means the same. They both have vertical joints, but the main feature of the olivine rock is a set of prominent planes dipping at a low angle to S. 30° E. or thereabout; the lighter-coloured diabase has oblique joints dipping about W. 20° S. and at a steeper angle. So that, from the strike of the joints and the form into which the exposures weather, one can tell at a glance whether an outcrop is olivine-diabase or not.

At the N. end of Mynydd Penarfynydd the blocks which lie on the crest are not all actually *in sitû*, so that the boundary cannot be laid down precisely; they are mostly here diabase. Still the olivine-diabase at its N. termination must abut against the fossiliferous shales which extend from the farm below partly up the slope. Indeed, there is little doubt of its being intruded through them, for the shales which immediately S. of Penarfynydd farm are black, soft, and fossiliferous, are seen 100 yards further S.W. on the mid-slopes getting paler and harder, as if altered by baking. The N. end of the ridge which stands steeply almost immediately over the farm, and perhaps 100 feet above the fossiliferous shales, consists of pale-yellowish flaggy beds, with grey minute spots, apparently a further stage in the same process of change: they are here in contact with the diabase certainly, but perhaps also with the olivine-diabase, as the junction must be close. There is therefore, presumably, a double contact alteration, that of the crest certainly due in part to the diabase, and that on the W. mid-slope indicating a similar action on the part of the olivine-diabase.

If this be so, there need not be much difference in time between the two diabases, since they might both belong to the same epoch; but I presume that the lighter-coloured diabase of Mynydd y Graig was the older, and that it was thoroughly consolidated before the intrusion of the olivine-diabase. This seems suggested by their relations in the promontory described: another fact tending in the same direction is the occurrence of a black rock, poor in felspar, in the ridge where the word Careg llefain stands on the map (a microscopic analysis is given below). It is, from its position, apparently intrusive; I did not delay to trace its boundary, and had no opportunity of returning to it. [P. 84–5] are labelled "under Penarfynydd." A similar rock [P. 81–3] is labelled "W. end of Hell's Mouth." This may be taken to mean Penarfynydd ridge, or possibly near Rhiw; in the latter case it would show a second intrusion of this rock.

Fossils were found in an opening at the back of Penarfynydd farm, the beds being a black softish pencil slate, with small specks of mica; their appearance was suggestive of Arenig. Determinable were *Trinucleus Etheridgii*, Hicks, *Didymograptus bifidus*, Hall; there was also a small *Obolella* most like *O. sagittalis*, badly preserved, and a tail of *Barrandea* with such a wide margin that I cannot refer it to any described species. The above fossils show the date of intrusion of the igneous rocks to be subsequent to Upper Arenig times. The dark shales around Llanfaelrhys are noted on the Survey Map as fossiliferous, and in Prof. Ramsay's Survey Memoir (p. 173, 256–7) are cited from Llanfaelrhys "in flaggy beds which resemble the Tremadoc slate" *Ogygia Selwynii*, *Graptolites sagittarius*, *Obolella* 2 sp. One of the latter (*ib.* pl. 12, fig. 6) is probably the same as the one found at Penarfynydd.

Olivine-diabase from Penarfynydd.—The specimen which I had sliced was from the top of the ridge; it has felspar, but less serpentine and olivine, differing thus from Sedgwick's specimen numbered [P. 85]. The hand-specimen reminds one of Baste rock, being dark in colour, and the bright cleavage planes of the bisilicates, interrupted by dull portions of the ground obtruding through them; generally greenish to brownish-black, with a few white spots of felspathic matter (in another specimen in local patches, the serpentine and bisilicates almost exclude other constituents): no effervescence with acids: it is identical with [P. 84].

Microscopic examination.—The rock consists largely of olivine crystals of rounded outline, and inclosed as separate crystals in felspar, pyroxene or hornblende; they are mostly very fresh, but some of them pass into serpentine in the usual manner with magnetite segregation, they always show the characteristic fissures, the first resort of serpentinous decay. The most abundant constituent perhaps is a pale-yellowish augite, much like the Radauthal one in appearance, with rather distant cleavage; it forms large sheets and smaller detached portions; some basal sections are seen; it is frequently intruded on by the olivines, which indent it or are inclosed within it. When undergoing decomposition it seems to be first crowded with magnetite grains, and then passes to a pale green or colourless substance, with very feeble doubly refractive power; this is occasionally surrounded by zeolitic fibrous crystals. Hornblende is present, forming a few large sheets of most strongly dichroic character, changing from brownish-yellow to clove-brown when the vertical cleavage is parallel to the vibration direction of the lower Nicol. Though no basal section was observed in the slice, the mineral has all the characters of hornblende; the divergence of the elasticity from *c* axis was about 19°. The felspar is almost entirely decomposed to a white opaquish substance with occasional zeolitic formations; clearer lines in the granulated matter indicate, however, its triclinic nature; it incloses olivine and fills up spaces between other crystals. Two crystals of brown mica were found in the slice; it is abundant enough, however, to be visible to the eye in the hand-specimen.

For a diabase it is rich in olivine, and by this it differs from the next following rocks, to which it has some resemblances in other ways. Notwithstanding some little doubt about the nature of the pyroxene, I have ventured to class these rocks with the diabases; others from abundance of hornblende might prefer to call them proterobase.

Hornblendic diabase, in appearance somewhat similar to the Penarfynydd rock; as noticed above, it forms part of the ridge near Careg llefain: the hand-specimen is blackish-brown to black, with cleavage planes of augite about $\frac{1}{2}$-inch long, but no serpentine and scarcely any felspar; iron pyrites is seen scattered about. Slight effervescence with acid.

The microscope shows that hornblende is now the main constituent; it forms large sheets limited by the adjacent minerals or inclosing them; the vertical cleavage is well developed, while abundant basal sections give a prism angle of about 124°; it is very strongly dichroic, precisely as in the last rock, but is here much more abundant; from pale yellow it becomes clove-brown when the *c* axis is parallel to the short diameter of the polarizing Nicol. The hornblende and pyroxene alike pass into alteration products; hornblende first into a green dichroic substance preserving the original cleavage; then, as the structure becomes lost, iron separation sets in; a serpentinous substance is formed in part, while the bulk is a pale-green viridite of feeble doubly refractive power.

The relation of the hornblende to the pyroxene is not quite the same as that described by Prof. Bonney (Q.J.G.S. vol. xxxiii. pp. 895, 912) in Balk and Coverack gabbro, Cornwall, neither has it the green colour except where undergoing change.

Almost equal in amount to the hornblende is a pale-yellowish augite, not dichroic, the extinction angle about 35°, not a close lamellar cleavage, but rather distant usually (nearly rectangular in basal sections). The augite is intimately connected with the hornblende, sometimes its crystals are almost entirely surrounded by the latter, or scales of hornblende of shadowy outline are scattered in it, showing penetrating intergrowths; possibly the hornblende is partly a paramorphic change of augite, but I presume most of it to be original.

Plagioclase exists in the form of prisms, or larger masses filling interspaces, generally as prisms inclosed in or penetrating the bisilicates; it is much attacked by alterations, and often quite an opaque granulated substance; the crystals are frequently crossed by cracks of green chloritoid matter; sometimes they are partly replaced by quartz. In some tracts, where traversed by quite a network of the green veins, they appear very fresh, polarizing brightly. Titaniferous iron is abundant.

I regret not having any of the foreign hornblendic gabbros for comparison, such as have been described from Le Prese, or protero-bases, such as have been described from the Fichtetgebirge, and by Dr. Stache from the Zwölfer-Spitz district (Jahrb. k. k. geol. Reichsanstalt, 1877, vol. xxvii. pp. 207–216). To Prof. Bonney I am indebted for the loan of thin slices of Cornish gabbros showing the paramorphic origin of hornblende. As gathered from his description too, they lead me to consider the present case as of quite a different kind.

Diabase of Mynydd y Graig, etc.—Of the diabase, a piece was selected from the quarry beyond Plas Rhiw as likely to be fresher, and it seems the same type of rock all down to Penarfynydd Promontory. The crystals are of medium grain, no large ones among them; a brownish-grey rock speckled with much white, the bronze-coloured pyroxene and felspar about equal: the white part effervesces abundantly with acid, and is sometimes discoloured to a pale-green.

Microscope.—The bulk of the rock consists of augite of pale-yellowish tint in thin sections, which polarizes vividly; most of the crystals are developed at their margins into or sometimes penetrated by dichroic brown hornblende, not quite so strongly dichroic or so well pronounced as in the last rock, and of rather dull doubly refractive power compared to the augite. As not unusual in such cases, the two intergrown crystals are orientated in the same manner, and in one compound crystal we obtained a maximum extinction angle of 36° for the augite, and about 16° less for the hornblendic portion. One pale crystal behaving like an orthorhombic mineral is supposed to be an orthodiagonal section of the augite rather than another species. Undergoing change the hornblende becomes full of crowded grains of magnetite collected together and surrounded by an irregular area of fibrous zeolitic crystals, while in the centre may be a colourless tract of very feeble doubly refractive power, under crossed prisms the indigo black showing only slight change during revolution of the plate.

These rocks are noticed in the Survey Memoir (*l.c.* p. 174) as varieties of greenstone, which "further north and west of Mynydd y rhiw passes into syenite." This is a view entirely different from that of Dr. Hicks mentioned above.

The next two rocks are also recognized as intrusive (*ib.* p. 174–5).

The slates which are described as dipping under the greenstone of Pen y cil are there ascribed to the Bala series with some doubt. I was unsuccessful in the search for fossils in the black slates in which the Aberdaron mass is intrusive, but they may turn out possibly to be Lower Bala (Sedgwick).

Diabase from greenstone patch on map below Tynyrhedyn S. of

Llanfaelrhys.—It differs sufficiently from the larger mass close by to justify the mapping, even if the black shales were not seen in the ravine on the W. An apparently fresh piece shows numerous black spots like delessite, with smaller ones of magnetite in a sap-green coloured ground of rather fine grain. No effervescence with acid.

Microscope.—Plagioclase seems the most abundant constituent; it still preserves its banding, but only shows dull colours; the prisms, etc., are arranged as in any dolerite. They are full of very long slender microlites with a slight greenish tint, and are like those often referred to tremolite. The augite is gathered together in compound groups and also scattered throughout in crystals of moderate size; they are much attacked by decomposition, but the parts left unaffected polarize brightly.

A large portion of the slide is taken up with viridite areas, some of large size with a somewhat scalloped outline, and banding arranged parallel thereto (as in an agate); it has no dichroism, and is dark indigo under crossed prisms; it exists also in smaller portions scattered throughout the slide. There is a fair quantity of black oxides of iron, some titaniferous changing to leucoxide, some forming long linear crystals remain jet black in reflected light and are probably magnetite. There is also a good deal of dirty matter about the slide, granulated material discoloured by iron oxide; this arises no doubt largely from augite, but may partly also be the remains of a glass which has disappeared.

This mass is intruded into shales which, as noted above, must be Tremadoc or Arenig. I was unsuccessful in finding fossils in the immediate neighbourhood.

Diabase, quarry at top of Aberdaron village.—A dark green rock with narrow needle prisms of felspar; no effervescence with acid. The rock is very much like the next one from Penycil except that delessite spots are here more abundant and larger. Pyrites is seen in the hand-specimen, which is of medium grain.

In the Sedgwick collection is one [P. 34] which is from near Aberdaron, five miles to the north, being labelled "hill close to Mr. Thomas' house," Trefgraig farm: it is somewhat similar to these bosses (which are only distant on the map about 1½ miles)—its augite a little larger. As its felspars are much decomposed, I chose instead the specimen obtained fresh from the interior of Aberdaron quarry for slicing.

Microscope.—The plagioclases form the bulk of the slide arranged in the form of long prisms; they retain a certain amount of freshness, as evidenced by brightly polarizing qualities; they contain in great abundance pale greenish microlite needles set in various directions. The augite is in a minority, the crystals small, of corroded outline, scattered through the slide, and seem mere remnants.

Viridite tracts occupy a large proportion of space; they are slightly dichroic, showing light green and pale salmon colour, of radiating fibrous structure, which show aggregate polarization of bright tints; smaller patches are scattered through the slide, and it permeates everywhere. Abundance of opaque ferric matter, particularly round the augites.

Diabase, from Penycil Promontory, a mass intrusive in Harlech Grits according to the Survey Map; the specimen sliced was taken from a little quarry near the S. end, and has the appearance of being fresh; it effervesces slightly with acid; it is dark sap-green in colour, with lustrous felspathic needles, pyrites, and minute segregations of zeolite occasionally.

Microscope.—The long felspar prisms show banding, but have only a dull salmon colour when polarized; many are much decomposed and permeated by viridite, or are corroded by areas showing zeolite and even calcite re-arrangements. The augite forms crystals of considerable size between the felspars, are without regular outlines, and have cracks, and their ordinary characters; are pale yellow in the thin slice, and polarize brightly. Many, however, are visibly decomposing, they pass into viridite; this is scattered about in flakes everywhere, and also forms tracts of larger size; it has under crossed Nicols a granulated appearance of dark indigo-grey, with in some places radiated fibrous circles showing the black cross; some of these tracts are bordered by a botryoidal denser lining of granular viridite substance, within which is the fibrous radiating variety with aggregate polarization.

Dendritic forms of black iron oxide with branches at right angles to the stem are present, besides crystals of ilmenite covered with opaque white oxide. E. B. T.

(*To be continued.*)

IV.—A Contribution to the Study of the British Carboniferous Tubicolar Annelida.

By R. Etheridge, Jun., F.G.S., F.R.P.S.Edin.

(*Continued from p.* 174.)

Observations on Spirorbis.—In the foregoing history I have endeavoured to give a brief and clear outline of the views held by those who have made it the subject of their investigations since the time of W. Martin.

Omitting this author, who undoubtedly looked upon it as a mollusc, we have first to consider the opinions of Murchison and Phillips, and there can be little doubt, I think, that, from the expressions made use of by these writers, they were quite conscious of the great affinity which *Microconchus* bore to the common *Spirorbis,* and hence to the Annelida. This is again apparent in the writings of Dr. Hibbert, although he called it a *Nautilus*; and when we take up Col. Portlock's work, we find the same form, with a similar habit, only under another name, and also a second species definitely referred to the genus *Spirorbis.* Following close upon these we have the researches of Dr. Dawson and Mr. E. W. Binney, rendering still clearer, if more evidence was needed, the Annelide,—or to put it in the very broadest sense possible, the Testaceous character of the organisms so clearly described by them. Under these circumstances it appears strange that such accomplished Palæontologists as Messrs. Germar, Göppert, Geinitz and others, should have been so ignorant of contemporary palæontological literature, as to refer this very well-defined little fossil to the Fungi. This view has been so completely disposed of by Dr. Dawson, Mr. Lesquereux, Messrs. Van Beneden and Coemans, and Dr. Goldenberg, that it becomes quite unnecessary for me to offer any remarks upon it. Beyond this, however, I cannot agree with Van Beneden and Coemans, and Dr. Goldenberg; for had their knowledge of the English and American literature of *Microconchus*, or *Spirorbis carbonarius*, been in any way equal to their acquaintance with the opinions held on the Continent, with regard to *Gyromices*, it is probable their line of argument would have been different. Strange to say, the former authors do not in their historical notice give a single direct reference to any English or American paper on the subject, and the latter author only does so once.

Microconchus, Murch., and *Palæorbis*, Van B. and C., are without doubt identical, and whatever view palæontologists may take of the affinities of these little bodies, the former name must, by the laws of priority, be retained for them. The resemblance borne by their *Palæorbis* to the recent *Spirorbis* evidently struck Van Beneden and Coemans forcibly; but they were unable to reconcile the occurrence of an animal of marine habit, like *Spirorbis*, associated with the remains of terrestrial or marshy plants. "But looking at the manner in which the whorls are formed and arranged, the regularity with which their volution is effected, and again the nature and aspect of the calcareous tube" (*gaine*, a sheath), "we are led to doubt their Annelide affinity, and, after mature reflection, we see in *Gyromices* pulmonate terrestrial molluscs."[1] Furthermore they add, "We are led to regard *Gyromices* as terrestrial Gasteropod molluscs, allied to the Helicidæ, and living attached to the leaves and stems of ferns, or other Coal-plants, in a similar manner to the existing *Spirorbis* upon marine plants and animals."[2]

Now, in the first place, as to the occurrence of *Microconchus*, or *Palæorbis*. We will take for example its presence in the Wardie Shales of the Lower Carboniferous Series of Scotland. There, as in other deposits, as has been described by various authors from W. Martin downwards, it is found infesting various plant-remains of terrestrial origin, in all stages of preservation, from a frond of *Sphenopteris affinis* sufficiently perfect to justify us in considering it as not long torn from the parent plant previous to entombment in its argillaceous matrix, to the well-macerated remains of Calamites and Coniferous leaves. *Microconchus* as readily attaches itself to the one, as to the other; to the frond showing traces of only recent immersion in the Wardie Shale waters, as to the frond with frayed edges to its pinnules, the Calamite with decorticated and frayed stem, and the leaves of *Cordaites* bent and broken. Is it, therefore, likely that the remains of a pulmonate terrestrial mollusc, as their *Palæorbis* is supposed to be, by Messrs. Van Beneden and Coemans, would be found in an equal state of preservation on portions of plants which had undergone long maceration previous to fossilization, as on those which appear to be of a more recent date in the same bed? Is not

[1] Bull. l'Acad. R. Bruxelles, 1867, xxiii. p. 389. [2] *Ibid.* p. 390.

this a character one would more readily expect to find associated with an ally of *Spirorbis*, to which it would matter little whether its object of attachment had or had not sustained damage from continuous aqueous action?

Unfortunately for the argument of Van Beneden and Coemans, *Microconchus* or *Palæorbis* is as frequently found adhering to the surface of shells as to the fronds of ferns, and portions of other plants. Mr. E. W. Binney [1] long ago described the manner in which the *Unios* (*Anthracosiæ*) found on the roof of the Four-feet Mine at Bradford were covered with this little organism; and I have myself incidentally pointed out its like association with one of the bivalves of the Wardie Shales, *Anthracomya Scotica* (mihi). This and another allied form, *Anthracoptera obesa* (mihi), are sometimes so covered with individuals of *Microconchus*, that it is difficult to distinguish the shell itself. The beds connected with and about the horizon of the Burdiehouse limestone are particularly noticeable for this. The like has also been pointed out by Messrs. Armstrong and Young, who in their Catalogue of Scotch Carboniferous Fossils say, "Found adhering to plants and shells in many of the beds of the Upper Coal-measures." [2] Now, the association of *Microconchus* (or *Palæorbis*) with bivalves in the place of plant-remains seems to me simply fatal to the view that the former is a terrestrial pulmonate Gasteropod. Allowing, for the sake of argument, that those found on fern fronds are Gasteropods of this nature, and had become accidentally immersed with the plants to which they were attached, how does this account for their appearance on the surface of bivalve mollusca in the same deposit, not only adhering, but also forming for themselves a similar depression or groove in the substance of the shells?

To the facts now adduced by me, it may be advanced that I am endeavouring to prove as of a freshwater habitat, an organism which, like the living *Spirorbis*, is of marine affinities. To this objection it may be replied—it is an incontestable fact that during the deposition of the Coal-measures, incursions of the sea did take place, consequent on a change of level, as shown by the occurrence of marine bands, such as the Pennystone Ironstone of Coalbrookdale; [3] the Gannister Coal, near Oldham; [4] and a band over the Great Mine Coal at Ashton-under-Lyne, [5] containing marine bivalves and Cephalopoda.

During the deposition of the Wardie Shales precisely similar events took place. These beds are usually looked upon as of fresh- or brackish-water origin, but my own views have for a long time inclined much more to the brackish- than the fresh-water theory, after a prolonged and careful study of the organic remains found in them. Certain it is that definite and well-marked marine bands do occur, as, for instance, that at Woodhall, on the Water of Leith; another at Craigleith Quarry, near Edinburgh; another near Granton

[1] Mem. Lit Phil. Soc. Manchester, x. p. 196.
[2] Trans. Geol. Soc. Glasgow, iii. App. p. 23.
[3] Prestwich, Trans. Geol. Soc. 1840, 2nd ser. v. p. 442.
[4] Mem. Geol. Survey of Gt. Brit. Country around Oldham, 1864, p. 62.
[5] *Ibid.* p. 64.

Breakwater, on the shores of the Firth of Forth, and so on. But the important point of all is, that at Woodhall, in company with such forms as *Discina nitida*, Phill., *Serpulites carbonarius*, M'Coy, a *Chætetes*, *Lingula mytiloides*, Sow., *Bellerophon decussatus*, Flem., a *Murchisonia*, a *Pleurotomaria*, a *Conularia*, remains of *Orthoceras*, and numerous bivalves, we have our little *Microconchus carbonarius*. In other words, I believe we have in this worm, a form which, although of marine affinity, was able to maintain life in waters very slightly removed from fluviatile; and that immediately on slightly marine influences manifesting themselves, from physical causes, in lagoons, swamps, or brackish-water arms of the sea, in which certain portions of the Carboniferous strata were in course of deposition, *Microconchus* was one of the first to establish itself.

That I am not alone in considering *Microconchus* as of brackish-water habit, the following extract from one of Lyell's works will show:—"In the Coal-fields both of Europe and America the association of fresh, brackish-water, and marine strata with coal-seams of terrestrial origin is frequently recognized. Thus, for example, a deposit near Shrewsbury, probably formed in brackish water, has been described by Sir R. Murchison as the youngest member of the Coal-measures of that district. . . . The characteristic fossils are a small bivalve, having the form of a *Cyclas* or *Cyrena*, also a small entomostracan, *Leperditia inflata*, and the small shell of a minute tubicolar annelid of an extinct genus called *Microconchus*, allied to *Spirorbis*."[1]

The following passage clearly shows that in Mr. Salter's mind some doubt existed as to the exclusively *marine* character of *Spirorbis*. "At present all *Spirorbes* are marine, or, at the least, estuary shells, and their frequent attachment to stems of *Sigillaria*, and other coal plants, is a strong indication of the *habitat of the plants themselves*."[2]

In his able paper "On the Origin of Coal,"[3] Mr. E. W. Binney strenuously supports the marine origin of that mineral, as opposed to the exclusively freshwater, or swamp theory of its accumulation. He says,[4] "In a former paper . . . I have stated that the Coal-measures have presented some appearance of having been deposited in an estuary; but further observations, and the great superficial extent of the formation, now lead me to believe that they must be considered more of a *marine* character, and that the currents which brought the *débris* did not altogether proceed from the river running into the sea, or by tidal action, but were chiefly produced by the subsidence of the bottom of the ocean itself. The occurrence of the *Cypris* and the *Unio* in the Upper Coal-measures has been considered indicative of the freshwater origin of those strata; but when these fossils are found in company with remains of the *Megalichthys*, *Holoptychius*, *Cœlacanthus*, *Platysomus*, *Palæoniscus*, and other genera heretofore considered as of decidedly marine origin, their diagnostic value ceases, even if all of these genera were confined to fresh water; but it is well known that such is not the case, but that

[1] Student's Elements Geol. 1874, pp. 395–96.
[2] Iron Ores Gt. Brit. pt. 3, p. 227.
[3] Mem. Lit. and Phil. Soc. Manchester, 2nd ser. viii. pp. 148–194. [4] p. 184.

many are found in salt water." The bearing of these remarks on the question of the habitat of our *Spirorbis*, one of the most characteristic fossils of the Coal-measures, I consider to be of the greatest importance.

The observations of Dr. Dawson on the accumulation of the South Joggings Coal-measures, although given from a different point of view, are equally important. Considering them to have been deposited in swamps and lagoons, he says,[1] the events indicated by the S. Joggings section "consist of a long succession of oscillations between terrestrial and aquatic circumstances, and unaccompanied by any material permanent change in the nature of the surface, or in its organized inhabitants. . . . The results of these opposing forces no doubt always existed contemporaneously, so that by a mere change of place, one could have passed from a coal swamp to a Modiola-lagoon, or a tidal sand-flat; but in each separate locality they alternated with each other, with greater or less frequency, etc." Such alternations of an aquatic nature from salt to fresh or brackish water conditions would have been peculiarly fitted, I believe, for the development of such a form as *Micro. carbonarius*. My father has pointed out the co-occurrence of a purely marine Crustacean of the Limuloid type, *Prestwichia rotundata*, with *Micro. carbonarius*, in the Somersetshire Coal-field,[2] the latter being parasitic on the carapace of the former.

Finally, it is almost needless to observe, the Annelida are both marine and fresh water, and even amphibious, as, for instance, the Hairworm (*Gordius*). It is not impossible, therefore, that *Microconchus*, although of a different order, may have been so also.

Microconchus pusillus varies considerably within certain limits. The typical form is well illustrated by the four upper left-hand figures of Murchison's Siluria.[3] The variety with the last turn of the coil prolonged is equally represented by his two lower figures. Variation also takes place in the mode of attachment to foreign bodies—whether by only a portion of one side of the coil, seen as a groove in one of Murchison's figures, or by the whole of one side of the tube, which then becomes flattened. The surface ornamentation is equally subject to variation; it is at times almost plain, at others, with very numerous, fine, but regular and distinct direct transverse striæ, almost resembling microscopic ridges; whilst again in some specimens fine spiral striæ occur; this condition has been well figured by Murchison. I have not observed the beaded form of ornament described by Dr. Dawson as seen in Canadian specimens; this may, however, arise from the intersection of the fine transverse ridges and spiral striæ.

The tube of this species is dextrally coiled, but in many figures individuals will be seen scattered over the surface of a plant apparently sinistral. This appearance has been explained by Dr. Dawson, who, speaking of his *S. Erianus*, says that the tube will appear

[1] Quart. Journ. Geol. Soc. x. p. 29.
[2] Trans. Manchester Geol. Soc. 1866-67, vi. p. 124.
[3] "Siluria," 4th edition, 1867, p. 302, Fossils (83).

dextral, or sinistral, according to whichever surface of the leaf to which they are attached is held up, the remains of these Carboniferous plants at times being so thin as compared with the solid shell of the *Microconchus*, that the latter is visible through it. I am able to confirm Dr. Dawson's statement from an examination of specimens of *Sphenopteris affinis*, L. and H., to which the worm tubes were adhering on both sides.

Many examples of *Microconchus pusillus*, when clear of matrix, really appear as if free, and unattached; this, however, results from the smallness of the surface by which adherence took place. When fixed by the whole of one surface, that face of the tube is quite flat (Pl. VII. Fig. 2); but when adhering only by a portion of the attachment-surface, the inner whorls of the coil more or less protrude (Pl. VII. Fig. 5), and are, to a certain extent, piled; or, in other words, as Messrs. Van Beneden and Coemans say of their *Palæorbis*, the attached side then shows more whorls than the other.

Usually, at any rate in the typical form, the circular mouth of the tube ends off short; if however perfect specimens are luckily obtained, the tube will be found to extend itself as a short free termination, and is sometimes directed more or less to one side (Pl. VII. Fig. 9).

The size of the tube of this species varies greatly. I have observed it varying between that of a pin's head and a diameter of 3·5 mm. in an ironstone from Tamworth.

If I understand Dr. Geinitz's description of *Gyromices* correctly, it is said to be chambered. The expression he uses is "mehrkammerigem Perithecium,"[1] a many-chambered Perithecium. Substitute tube, or shell, for "Perithecium," consequent on the non-fungoid nature of *Gyromices*, and we have it described as a many-chambered shell. This our *M. pusillus*—which I believe to be identical with *G. ammonis*—is not. It may be that I do not comprehend the word "mehrkammerigem" correctly used as it is here in a botanical sense, but in the ordinary acceptance of the term it would define the tube of *Gyromices* as divided into several chambers by partitions or septa.

I have satisfied myself by means of sections taken in the plane of the coil that *M. pusillus* is non-septate, bearing out, in this respect, the statement made by Van Beneden and Coemans that their *Palæorbis* is unprovided with any diaphragms.

The abundance of this little worm in certain localities is almost incredible, whole beds of limestone being almost composed of its remains. Some idea may be formed of its plentitude by Mr. J. Young's statement that he had counted on a single plant from the Airdrie Coal-field no less than three hundred individual tubes adhering to it.[2]

Under the name *Microconchus pusillus*, Martin, I have united in the foregoing synonymy the British *M. carbonarius*, Murch., the American *Spirorbis carbonarius*, Dawson, the German *Gyromices ammonis*, Göpp., and the Belgian *Palæorbis ammonis*, V. Ben. and Coemans. This may not be acceptable to all palæontologists; but I have done

[1] Verstein. Steinkohlenformation in Sachsen, 1855, p. 3.
[2] Proc. Nat. Hist. Soc. Glasgow, 1868, i. pt. i. p. 102.

so after mature reflection and the examination of a very large number of specimens. The trivial differences which may perhaps be found between any two of these, or between the whole collectively, cannot, I think, be considered of much importance in the specific diagnosis of such very variable animals as Tubicolar Annelida. In all the tube is dextral and adherent, is frequently found imbedded in the substance of the body to which it is attached, and within narrow limits the surface ornamentation is identical. I am fortified in this reference by the opinions of Drs. Dawson and Goldenberg. The former states that the Canadian form is "apparently not specifically distinct from *Microconchus carbonarius* of the British Coal-fields,"[1] whilst the latter informs us that the American *Spirorbis* is identical with that met with in the Saarbruck Coal-field.[2]

Col. Portlock, and following him Prof. M'Coy, referred to the Devonian species *S. omphalodes*, Goldf., a form found in the Carboniferous System of Ireland. Their remarks, especially in reference to the impressions left by the tubes on the surface of plants, lead me to the conclusion that the forms described by them are identical with the present species.

Loc. and Horizon.—It is unnecessary to mention the host of places at which *Microconchus pusillus* has been met with; but the following may be taken as representative ones, both in a geological and geographical sense.

In a bed of limestone, associated with and adhering to bivalves, seen in a quarry on the Linnhouse Water, opposite the Oakbank Oil Works, near Mid-Calder; in Cyprid shale, associated with and adhering to plants and bivalves (*Anthracomya Scotica*, mihi, and *Anthracoptera obesa*, mihi), at Straiton Oil Shale Works, near Burdiehouse, and in fact about the horizon of the Burdiehouse beds generally (*Mr. J. Bennie*). In the Burdiehouse Limestone, at Burdiehouse (*Mr. C. W. Peach*). R. Tweed, below Coldstream Bridge, adhering to bivalves (*Mr. A. Macconochie*). In Estheria shale at Lammerton, Berwickshire (*Prof. T. R. Jones*). These horizons are all in the Cement-stone Group of the Calciferous Sandstone Series of Scotland.

In the Bo'ness Upper Ironstone, at Kinneil, near Bo'ness, of the Middle Limestone Group (= L. Coal-measures of some authors), of the Carb. Limestone Series of Scotland (*Mr. J. Bennie*). In freshwater and estuary limestone of the Campsie district, in the L. Carb. Limestone Group of Scotland (*Messrs. Young and Armstrong*). In freshwater limestone above the Main Coal at Carluke (*ibid.*) ? In the Shotts Upper Cannel or Gas Coal, at Trees, near Bathgate; shales over the Virtuewell Coal, at Windy Edge, near Shotts Kirk; shales over the Airdrie Black-band Ironstone, at Darngavel, near Airdrie (*Mr. J. Bennie*). These horizons are all in the Coal-measures of Scotland. In the Blue or Big Vein Ironstone at Sirhowy, and in the Spotted Vein Ironstone at Beaufort, in the S. Wales Coal-field

[1] Acad. Geol. 1868, p. 205.

[2] Fauna Saræpontana Foss. 1877, heft 2, p. 6.

(*Mr. J. W. Salter*). In the limestone at Ardwick, near Manchester, Upper Coal-measures (*Phillips, Binney, Salter*). In a bed thirty yards above the Arley Mine, Middle Coal-measures, at Bolton-le-Moors (*Mr. J. W. Salter*). These localities are in the Coal-measures of England and Wales.

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

V.—On the Pre-Cambrian Rocks of West and Central Ross-shire.

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

With Petrological Notes.

By T. Davies, F.G.S., of the British Museum.

Part III.

Glen Laggan and Glen Docherty.

THE rocks described by Mr. Davies in Notes 15–20 belong to the newer series, and were collected as nearly as possible at the points indicated in the sections. They are here described for comparison with the older rocks already referred to, and with the rocks to be further mentioned to the east of this line. I selected intentionally for examination those which appeared most highly altered, or otherwise to have any resemblance to the old rocks; as it is well known that Prof. Nicol considered them to belong to that series, and not to the newer groups. The petrological evidence as given by Mr. Davies proves that they are in no way allied to the gneiss rocks of the old formation, and that they are not sufficiently metamorphosed to be allied to any schists of known Pre-Cambrian age in these areas. These facts, combined with the physical evidence of the discordance in strike also almost everywhere apparent, seem therefore conclusively to prove that they cannot be of Pre-Cambrian age, but that they belong to a much younger series, and overlie the limestone group found along the west side of Glen Laggan.

Nos. 17 and 18 were collected almost immediately upon the limestone, in the line of Section III., and hence at a lower horizon in the succession than the others. There can be little doubt that these at least form a part of that group. They are flag-like in character, of a dark bluish tint, and sometimes of a very fine grain. They alternate, however, in some places, with almost pure sandstone bands. Near the diorite they are considerably twisted about and crushed. The usual dip is to the S.E., and here at a moderately high angle. There is distinct evidence of considerable disturbance and faulting at this point. The next series, *f*, though not actually seen here to repose upon the limestone group, appear undoubtedly to overlie some comparatively unaltered sandstones and flags, and, I believe, unconformably. If these belong to the limestone series, then the evidence seems to show that we have a physical break at this point in the succession. If this is a fact, much of the difficulty experienced in unravelling the sections to the N. and S. along this line is easily explained. In some it would appear as if the limestone group was altogether absent, whilst in others this would be seen to spread out perhaps to a great thickness, and from all the evidence that has been collected this seems to be very much the case. Moreover, there are some indications also of an actual overlapping of the limestone beds by some flaggy sandstones towards the upper end of Glen Laggan, along the west side; but further examination is necessary before this can be accurately ascertained. In Section II. the unconformity between the series *f* and the sandstone below is tolerably well marked.[1]

The rocks examined, belonging to groups *e* and *f*, seem to be about equally altered along this line, being most so when in contact with igneous dykes, or faults; and scarcely at all, or not more so than is usual in rocks of Silurian age in other areas, when unaffected by these causes.

Along the east side of Glen Laggan the groups *e* and *f* are seen at several places to rest upon the upturned edges of the Pre-Cambrian rocks. The latter composed mainly of granitoid gneiss and dark mica schists, as described in Notes 13 and 14. These strike from N.W. to S.E., and are therefore entirely discordant to those which repose upon them. This same discordance in the strike of the beds, and difference in mineralogical characters, may be traced eastward in Glen Docherty, with but slight interruptions only from want of exposures, for several miles. The lower rocks everywhere a highly metamorphic group, with a high dip and a strike from N.W. to S.E.; and the upper unequally altered, never for any distance truly metamorphic, and always at a low angle, and with a strike from N.E. to S.W. Towards the upper end of the Glen the lower rocks are seen to ascend to a considerable elevation, and are there cut through by the road where it begins to descend into the Glen. These lower rocks at this point consist chiefly of reddish highly felspathic gneisses, described in Notes 21 and 22.

[Note 21.—Is macroscopically exceedingly fine-grained, almost compact, of a reddish colour, consisting of felspar, and shows no indications of foliation. The microscope shows that it is composed of closely developed crystals of felspar, almost wholly orthoclase, which is much decomposed; the interspaces, which are small, being occupied with quartz and calcite. The latter also fills fissures, and is of secondary origin. No mica is present, unless a yellowish-grey nearly opaque substance may be regarded as representing this mineral. A pale-coloured garnet, in very small crystals, is scattered throughout. Indications of a tendency to a foliated structure, though not striking, are not wanting.—T.D.]

[Note 22.—A fine-grained rock, of a reddish colour, with much red felspar and a colourless mica.

A thin section discloses intimately crystalline quartz in wavy bands, with much decomposed felspar, which is principally orthoclase. The colourless muscovite, though occasionally in fairly continuous bands, is also generally distributed in isolated laminæ,

[1] It is however too strongly indicated in the section, and carried up too high into the cliff.

which, however, are approximately parallel to the plane of foliation.—T.D.]

No one, I think, can read Mr. Davies's descriptions of the rocks 13 and 14, and 21 and 22, which mainly make up what I consider the Pre-Cambrian floor along this line, and not realize that they are petrologically very unlike those described by him in his Notes 15–20, from the higher beds along the same line. The latter in all cases, it matters not from what part they are selected, always contain fragments unchanged, and have their detrital origin still well marked; whilst the former are always crystalline throughout, and retain little or no indication of their original condition. It has been supposed by some, since I first pointed out this discordance in the strike of the upper and lower rocks in Glen Docherty, that it is entirely due to faulting, and that the upper beds with a low angle of dip and a N.E. strike have been twisted so as to appear below at the high angle and with a N.W. strike. If this occurred at one point, or for a short distance only, it might perhaps be possible; but that it should extend for several miles, and include both sides of the Glen, is, I venture to say, highly improbable, if not utterly impossible; and those who have made the suggestion could not, I think, have attempted to realize the physical difficulties of such an occurrence. Moreover, as explained above, the petrological evidence also is opposed to such a view.

I have to express some regret for having allowed the section in my former paper to appear without a fuller explanation, though I clearly stated in the discussion that it was "a rough diagrammatic one," and that the angle at which the beds were drawn was much too high. The dip intended to be shown also was only for the escarpment in Glen Laggan, and its continuation at that angle eastward was a pure mistake. Section II. in the present paper, taken further south in Glen Laggan than the former one, and more immediately along the Glen Docherty heights, will explain more clearly what was there intended to be shown. I believe, however, that few only of those who read my former paper intelligently have found any difficulty in realizing what was meant; but as some have apparently failed to comprehend what was intended, I trust the present illustrations will enable them to do so. The following passage, taken from my former paper,[1] appears to me sufficiently explicit on this point, and should have prevented any misapprehension, though the section was accidentally distorted:—"The question as to how the Silurian rocks could have been brought into the positions indicated in the latter part of the section, is a difficult one. Is it the result of a natural overlapping of the older rocks eastward by these newer rocks? or have they been brought into this position by faults? I saw no evidence of faults of sufficient magnitude to bring them to this position alone; but minor faults there are undoubtedly, and these have in some cases considerably altered the position of some of the beds. On the whole, however, the evidence seems to show that these Silurian beds have been deposited on the eroded edges of the

[1] Quart. Journ. Geol. Soc. vol. xxxiv. p. 816.

lower gneiss rocks nearly in the positions in which they are now found, the present inclination of the beds being dependent upon subsequent movements, accompanied by some faults. These upper beds are undoubtedly made out of such materials as would be derived from rocks similar to those which now underlie them, and to which they are unconformable; and hence it is that sometimes a superficial examination may possibly lead one to associate them. The persistent and equal metamorphism, the contorted character, and high N.W. strike of the lower series is so marked, however, that for any distance it seems almost impossible to confound them in any way with the comparatively undisturbed and unequally altered beds of the upper series, which also almost invariably strike in the opposite direction, or from N.E. to S.W., *at a low angle of dip*."

That these beds gradually assume a more horizontal position as we ascend the Glen eastwards is undoubted. The high dip given to them in the section by Murchison and Geikie[1] is certainly not warranted by examination, except for a short distance near the escarpment; nor indeed would it appear at all reasonable, for the thickness required under these circumstances would be enormous, especially as these beds are indicated by them in other sections along this line to underlie the rocks composing the great mountains to the east. In some of the sections given by these authors the conformable thickness shown is truly appalling, and, I need hardly say, physically impossible, when we take into consideration the conditions which must have prevailed over these areas when the sediments were deposited. If these rocks were to underlie those to the eastward as supposed, one would naturally ask at first what would be the amount of faulting necessary for so sudden a change, if, as most agree, the old floor is still traceable as far at least as the east side of Glen Laggan. Considering also that the conformable sequence shown in most of their sections[2] cannot be less than ten miles (in one at least twelve miles), and usually at a dip of from 40° to 50°, and that all the sediments must have been deposited horizontally, one is not only astounded at the faulting necessary, but beyond all at the physical conditions required to allow such an accumulation of sediments. It seems to me perfectly clear that no attempt could have been made to realize the physical difficulties necessary to uphold this theory before it was propounded. That these sections also should have been so frequently reproduced, not only to show the supposed succession along this line, but also in a more or less modified condition for other areas, is truly remarkable!

These beds, according to my reading of the section, not only gradually assume a horizontal position, but terminate in the Glen which separates Craig Roy from Ben Fin; and instead of dipping under the latter mountain as supposed, overlie horizontally, or with a slight inclination only, the rocks near its foot, which form part of the Pre-Cambrian floor.

[1] Quart. Journ. Geol. Soc. vol. xvii. p. 191.
[2] Quart. Journ. Geol. Soc. vol. xv. p. 260; *ibid.* vol. xvii. p. 212; "Siluria," 4th ed. pp. 169 and 172; and Sec. i. in Geol. Map of Scotland (Geikie), 1876.

In the open ground which extends between the top of Glen Docherty and the western edge of Ben Fin, the old floor is traced with some difficulty; but on reaching the latter point, it is seen with all the usual characters recognizable in the more western areas.

(To be concluded in our next Number.)

NOTICES OF MEMOIRS.

Considérations géologiques sur l'Origine du Zand-Diluvium, du Sable Campinien et des Dunes Maritimes des Pays Bas. Par Dr. T. C. Winkler. Extrait des Archives du Musée Teyler, tome v. (Haarlem, 1878.)

In the above paper on the drift deposits of the Netherlands, Dr. T. C. Winkler treats of the origin of the Drift sand, Campinien sand, and Maritime dunes of the Pays-Bas. These deposits had been previously described and divided, by Dr. Staring, in 1853, as the drifts (diluvium) of the Meuse and the Rhine, the northern drift, and that of Munsterland. Again, in 1860, the same author classed them in three categories, the sandy drift (*zand-diluvium*), gravelly drift (*grint-diluvium*), and loess. Subsequent researches and considerations by Dr. Winkler have led him to modify the views of Dr. Staring, and he proposes the following divisions for the diluvial deposits of the Netherlands: the northern, eastern, southern, mixed (*entremêlé*) and *remanié* drifts. The reasons for these subdivisions, and their lithological characters, are fully explained in the memoir, as also the nature and distribution of the maritime dunes. From the facts stated, and the reasonings based upon them, Dr. Winkler considers he has shown:—

1. That the *zand-diluvium* of Staring ought to be termed the *remanié* drift, and that it was not formed, as Staring said, by the action of rain and frost, nor as Godwin-Austen said, by the action of wind, but by the effects of the sea.

2. That the *remanié* drift of the Netherlands is analogous to the Campinien sand of Dumont, in Belgium.

3. That the southern drift of the Netherlands is analogous to the flinty drift of Dewalque, to the *silex et cailloux* of Dumont, to the Campinien sand with rolled flints of Omalius d'Halloy, to the lower stage of the Quaternary period, the rolled flints and gravelly sand, of Dupont.

4. That the deposits of the Campine ought not to be considered as being simply composed of sand with pebbles, and sand without pebbles, but that these two stages ought to be separated according to their very different origin; the one, lower, coming from the Ardennes and the Condroz by means of rivers; the other, superior, being a marine formation, derived from older drift deposits by the action of the sea.

5. That the Campinien sand is posterior to the Hesbayen clay.

6. That the sand which constitutes the maritime dunes is identical with the Campinien sand of Belgium, and to the *remanié* drift of the Pays-Bas.

7. That the band of moving sands, which has been the source of the present dunes, was formed after the formation of the drift in the Netherlands, and consequently at the latter period of the Glacial epoch, or after this period.

8. That the alluvial deposits of the Netherlands are posterior to the formation of the maritime dunes. J. M.

REVIEWS.

I.—Mémoires pour servir à l'Explication de la Carte géologique détaillée de la France. Le Pays de Bray. Par A. de Lapparent, Ingenieur au Corps des Mines. (Paris, 1879.)

THIS memoir, the result of many years of labour, undertaken for the preparation of the Geological Map of France, is descriptive of the Pays de Bray, a district (from its peculiar features) of considerable interest to the geologist.

The memoir consists of three parts, which treat respectively, of the physical features, the succession of geological formations of which the region is composed, the elevation of the district, and its connexion with other disturbances in the Paris basin. The Pays de Bray has long engaged the attention of geologists. Noticed by O. d'Halloy in 1813, its structure has been further described by Elie de Beaumont, Graves, Passy, Cornuel, Hébert, and Barrois. But the study of the district has been beset with much difficulty, for the region is covered by woods and pastures, and divided by thick hedges and a great number of inclosures of very difficult access. With no stone quarries, the geologist can only avail himself of sand-pits, or of clay-pits opened for the manufacture of different kinds of pottery. However, the improvement of roads, fresh openings of the surface, and constructing railways during the last fifteen years or more, have materially assisted a better knowledge of the country. The railway from Rouen to Amiens traverses the Pays de Bray at right angles to its chief elevation, and two others, from Beauvais to Gournay, and from Gournay to Neufchâtel, follow the longitudinal axis, so that the district "so long isolated in the middle of Normandy as a sort of quagmire, almost forsaken by observers, is at the present time one of those affording valuable results, although the thick herbage over a large area still prevents the direct study of the subsoil."

The Pays de Bray, or Valley of Bray, is not an ordinary valley, but, like the English Wealden area, a so-called valley of elevation and erosion; it is an elongated semi-elliptical opening or trapezoidal amphitheatre contracted at both ends, extending from St. Vaast on the north-west to Tillard south of Beauvais on the south-east; the longer axis is about 40 miles, and that of the smaller 30 miles. It is not, however, an elevated dome, but its structure is due to a rectilinear dislocation, fault or sharp fold, a true line of rupture, around which are grouped a number of secondary effects (p. 132).

A transverse profile of the Pays de Bray shows three principal divisions: 1. A plateau or terrace, the *zone* of villages. 2. An undulating surface, the *zone* of forests. 3. A ridge or crest forming *Haut Bray,* which attains an elevation of more than 600 feet. From this elevated *zone,* upon which some villages are situated, the sources of the Bethune, Seine, and Oise arise. The soil of the district is either marly, clayey or argillo-siliceous, so that a general argillaceous (*boueuse*) character prevails throughout the surface of the Bray.[1]

The second part treats of the geological formations and their characteristic fossils; for fuller details of the latter, the reader is referred to the work of M. Graves.

The formations belong to the Jurassic, Cretaceous, and Tertiary strata. The lowest Jurassic stratum is the Upper Kimmeridge (which forms the highest part of the Haut Bray), consisting of limestones, clays, and *lumachelle,* more or less sandy, with *Ostrea virgula,* the two latter being generally separated by a band of compact lithographic limestone; at one point, however, near Louvicamp, a lower zone (the Ptérocérien or Astartien) has been observed. The total thickness of the Kimmeridge in the Pays de Bray is estimated at 120 yards, or nearly double that assigned to it by M. Pellat in the Boulonnais.

The Portlandian is divided into three stages. The Lower stage consists of glauconitic grits and marly limestone, with *Anomia lævigata,* Sow., and *Ost. catalaunica,* Lor., corresponds to the Portlandian of the Barrois and of the Jura, and is considered to be the equivalent of the upper zone of Kimmeridge clay in England. The upper part is covered by a calcareous conglomerate of milky and dark quartz pebbles, which has a great resemblance to the conglomerate at the base of the Portlandian in the Bas Boulonnais; the thickness of this stage increases from 35 mètres at Neufchâtel to 50 mètres at Villembray.

The Middle Portlandian, composed of blue marls with large Ammonites, is of moderate thickness, and is considered to be the exact equivalent of the Portlandian clays with *Ost. expansa* of the Boulonnais.

The Upper Portlandian consists of ferruginous grits and sand, with *Trigonia gibbosa,* is of limited thickness (about 8 to 10 mètres), and corresponds to the Portland stone and sand of England. It varies in composition in the northern, central, and southern parts of the district; in the central area the fossils are frequently highly silicified.

The grits and sands of the Upper Portlandian are succeeded by a formation with a lacustrine facies, which M. Graves long since recognized as the equivalent of the Neocomian group of the Haute Marne and of the Jura. The lower stage of white sands and refractory clays is, by its mineral character and the remains of ferns it contains, very analogous to the Weald-clay of England. The clay (*glaise*), an essential element of this stage, has been largely worked. M. de Lapparent considers, from the special nature and irregularity

[1] It is from this character that the name of the region is derived, for the word *Bray* comes from Braïum, which, in the ancient language of Gaul, signifies *boue, marécage,* or *lieu humide.*

of the clay, that it is probably due to thermal origin; and cites the opinion of M. Dumont, who attributed to a geyserian origin the *Aachenien* deposits of sand and clay in the Hainaut, and which are considered to belong to the Wealden of England and that of Bray (p. 53). The Middle Neocomian, from 15 to 25 yards in thickness, is formed of sands, or ferruginous grit, and of more or less black shaly clay; marine remains are found in the sand (*Cardium subhillanum, Pleuromya neocomiensis*), and ferns (*Lonchopteris Mantelli*) in the clay, pointing somewhat to an estuarine origin. To these succeed the Upper Neocomian of variegated clays (*glaise panachée*), from 15 to 25 mètres, and which are largely worked for pottery. The Aptien, with *Ost. aquila*, d'Orb., succeeds; above which occurs the Albien, the lower part consisting of green sand from 20 to 40 mètres thick; the upper, or Gault, of variable thickness (6 to 30 mètres), and containing the usual characteristic fossils, *Am. splendens, Inoc. sulcatus, I. concentricus*, etc. Above the Gault is a deposit termed *Gaize*, about 40 mètres thick, which may be considered as a passage between the Gault below and the Cenomanien above; it is composed of clay-marl indurated by silica, the silica being partly in a gelatinous or soluble form (about 33 per cent.). The contained fossils are *Am. rostratus*, Sow., *A. auritus*, Sow., *A. falcatus*, Mant., *Pecten elongatus*, Sow., etc. Above the *Gaize* the Cretaceous deposits become more calcareous, and consist of the glauconitic and marly Chalk, and the nodular White Chalk.

The Tertiary strata are not well represented, but traces of the Lower Eocene occur on two sides of the Bray, which attest its former extension over the region now elevated. A chapter is devoted to the clay with flints (*argiles à silex*), which M. de Lapparent attributes to the chemical dissolution of the chalk; this clay varies in colour from brown to red according to the formation with which it is associated, and its age is referred to the end of the Tertiary period. The ancient and modern alluviums and turf-bogs are briefly described, and an interesting account of the variation of the Jurassic and Cretaceous strata, and their relation with those of the surrounding region, concludes the second part of the memoir.

The elevation of the Bray, and the movements to which it has been subjected, forming the third part of the memoir, are treated in considerable detail, and full of suggestive remarks and observations on the various parts of the district examined by the author, including the determination of the age of the elevation (p. 149), and its relation to the different geological disturbances of other parts of France[1] (p. 167).

The following is a *résumé* of the third part: "The dislocation which has given rise to the Pays de Bray forms part of a series of

[1] In alluding to the researches of MM. Hebert and de Mercey on this district, M. de Lapparent does not mention the important paper by Dr. C. Barrois (Sur le Terrain Crétacé Supérieur), in which that author concludes,—that the axis of Kingsclere is the prolongation of the axis of Artois, the axis of Winchester that of the Bresle, and the axis of the Isle of Wight and of Purbeck that of the Pays de Bray. See Geol. Mag. Dec. II. Vol. III. p. 514.

parallel disturbances, affecting the north of France from the Perche to the Artois, following a direction near to 130°. These disturbances are the result of a lateral compression which has produced, throughout this region, a succession of folds alternately convex and concave, or anticlinal and synclinal. Three of these folds, that of the Seine valley, that of the Bray, and that of Artois, have been particularly sharp, so that at many points faults have been produced. This effect has attained its maximum in the Pays de Bray, where the Normandy lip or side of the disturbance has been elevated at certain points more than 300 mètres above the Picardy side. Besides, throughout its course, this dislocation shows differences of intensity which appear to have an intimate connexion with the occurrence of former geological disturbances.

"The dislocation of Bray, like that of Artois, appears to have occurred towards the close of the Eocene Epoch, between the period of the limestones of Saint-Ouen and that of the gypsum. Subsequently the region has been affected by fresh movements, contemporaneous with the diversion of the Beauce Lake, which is shown by two systems of conjugate directions: the first is the north-east and south-west system of the valley of the Oise; the second, directed from west-north-west to east-south-east, is that of the hills of the Fontainbleau sands, as in the forest of that name in the environs of Paris. These two conjugate systems would be formed at the same time as the elevation of the Western Alps."

The memoir is illustrated by woodcuts, a neatly executed geological map, and three plates, showing the contours of the formations, and the principal hydrographic and orographic directions of the Pays de Bray. J. M.

II.—Sur l'Invariabilité du Niveau des Mers. By Dr. H. Trautschold. (Moscow, 1879.)

THIS author is not disposed to take anything for granted, but considers that doubting is the property of the learned. Thus, on reading an article wherein the fixity of the level of the seas since the beginning of geological time is assumed, he takes the opportunity of disputing the assumption.

His position is, that as certain parts of the earth's crust rise from the bottom of the sea above its level, this latter must get lower. The surface of nearly all continents has formerly been sea-bottom. This surface emerged from the waters, partly in consequence of upheavals, partly in consequence of the retreat of the ocean. Proportionate to the formation of continents, a part of the water of the seas was transported thither in the form of lakes, rivers, eternal snows, glaciers, and organic matter. Consequent on this process the water of the ocean is diminished and its level lowered. Proportionate to the cooling of the earth, ice accumulates near the poles, and upon the mountains, water is sucked more deeply into the crust, and the formation of hydrated minerals displays itself everywhere.

The author points out that the prejudice as to the stability of the sea's level has not always existed, and that in the middle of the last century de Maillet conceived a project for estimating the diminution of the water. He also quotes Pettersen (Geol. Mag. July, 1879, p. 298), who has shown, as regards Scandinavia, that the changes of that coast-line must have gone on quite uniformly in the tracts from the Varanger Fjord to Bergen, a distance of nearly 2000 miles, nor does there appear evidence of any portion of the peninsula sinking.

The subject is dealt with as an essay in favour of a certain thesis, and the points which tell against it are not brought into prominence; nevertheless, the pamphlet is a highly suggestive one, and contains much that is worthy of consideration on the part of geologists, by whom the "mouvement de bascule," so ably disputed as regards the Scandinavian peninsula, has perhaps been too frequently urged.

W. H. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

March 24, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communication was read:—

"The Newer Pliocene Period in England.—Part I. Comprising the Red and Fluvio-marine and Crag and Glacial Formations." By Searles V. Wood, Esq., Jun., F.G.S.

The author divided this part of his subject into five stages, commencing with

Stage I. The Red Crag and its partially fluvio-marine equivalent. The Red Crag he regards as having been a formation of banks and foreshores mostly accumulated between tide-marks, as shown by the character of its bedding. The southern or Walton extremity of this formation, which contains a molluscan fauna more nearly allied to that of the Coralline Crag than does the rest of it, became (as did also the rest of the Red Crag south of Chillesford and Butley) converted into land during the progress of the formation; while, at its northern or Butley extremity, the sea encroached, and an estuary extending into East Norfolk was also formed; during which geographical changes a change took place in the molluscan fauna, so that the latest part of the Red Crag proper and the earliest part of the fluvio-marine (both containing the northern species of mollusca and those peculiar forms only which occur in older glacial beds) alike pass up without break into the Chillesford sand and laminated clay, which form the uppermost member of the formation. He also regards the principal river of this estuary as flowing into it from North Britain, through the shallow preglacial valley of Chalk, in which stands the town of Cromer, and in which the earlier beds of Stage II. accumulated in greatest thickness. The forest and freshwater beds, which in this valley underlie the beds of Stage II., he regards as terrestrial equivalents of the Red Crag; and having observed rolled chalk interstratified with the base of the Chillesford clay in Easton-Bavent cliff, he considers this to show that so early as the commencement of this clay some tributary of the Crag river was entered by a glacier in the Chalk country, from which river-ice could raft away this material into the estuary. He also regards the copious mica which this clay contains as evidence of ice-degradation in Scotland having contributed to the mud of this river.

In *Stage* II. he traced the conversion of some of this laminated clay, occupying sheet 49 and the north-east of sheet 50 of the Ordnance map, into land, the accumulation against the shore of this land of thick shingle-beaches at Halesworth and Henham, and the outspread of this in the form of seams and beds of shingle in a sand originally (from its yielding shells in that region) called by him the Bure-valley bed, and which Prof. Prestwich recognized under the term "Westleton Shingle." As the valley of the Crag river subsided northwards as the conversion of this part of the Chillesford clay into land occurred, there was let in from the direction of the Baltic the shell *Tellina balthica*, which is not present in the beds of Stage I. The formation thus beginning he traced southwards nearly to the limit in that direction of the Chillesford clay about Chillesford and Aldboro'. The Cromer Till he regards as the modification of this formation by the advance of the Crag glaciers into the sea or estuary where it was accumulated, such advance having been due partly to this northerly subsidence, but mainly to the increase of cold. Then, after describing a persistent unconformity between this Till and the Contorted Drift, from the eastern extremity of the Cromer cliff (but which does not appear in the western) to its furthest southern limit, he showed how the great submergence set in with this drift, increasing much southwards, but still more westward towards Wales. The effect of this was to submerge the area of Red Crag converted into land during Stage I., so that the Contorted Drift lies upon it 50 feet thick, and to cause the retreat of the ice which had given rise to the Till to the slopes of the Chalk Wold; whence masses of reconstructed chalk were brought by bergs that broke off from it and were imbedded by their grounding in this drift, contorting it (and in those parts only) by the process. He then traced, in the form of gravels at great elevations, the evidences of this submergence southwards and westwards, showing it to have increased greatly in both directions, but mostly in the western; and he connects these gravels with the Contorted Drift by the additional evidence of one of these marl masses, in which he found a pit excavated near the foot of Danbury Hill, in the London-clay country of South Essex, and which hill is covered from base to top by this gravel. The gravel which thus covers Danbury Hill, of which the summit has an elevation of 367 feet, rises in North Kent to upwards of 500 feet; to between 400 and 500 feet on the Neocomian within the Weald; to 600 feet in North Hants (where it overlooks the Weald), and also in Wilts, Berks, and the adjoining parts of Bucks; to 420 feet in South Hants; to 540 feet in Oxfordshire; to 400 feet in Cornwall; to upwards of 700 (and perhaps 1000 and more) in the Cotteswolds; to 1200 feet in Lancashire, and to 1340 feet in North Wales. Eastwards, through Kent towards France, their elevation falls, and in the North of

France appears to be about 130 feet; from whence the evidences of the submergence are furnished northwards by the Campinian sands and the diluvium of North Germany and Holland.

In *Stage* III. the author traced the rise from this depression, the increase of the ice from the greater snow interception caused by it on the Pennine chain, and the consequent advance of the glacier- or land-ice. This advance gave rise to the Chalky Clay, which was the morainic mud-bank which preceded this glacier, and was pushed by it as it advanced and the land rose, partly into the shallow sea (where it covered and protected for a time the gravel which was synchronously forming there), and partly on to the land; and by the aid of maps he showed the islands that were overwhelmed by it. He then showed, by a line on a map, the limit up to which this ice, as it thickened, cut through and destroyed this first deposited moraine and the gravel which it had covered, as well as such beds of Stage II. as were formed there, all this material being pushed on to add to later deposited moraine. Outside this line the gravel for the most part remains undestroyed, its contents, particularly in the uppermost layers, showing that it was fed by the approaching moraine. By the level at which the junction of this gravel with the moraine clay occurs he traces the position of the sea-line at this time (towards the end of the formation), and finds it to rise along the south-eastern edge of the clay, from 40 feet in N.E. Suffolk to 160 feet in South Essex, and from that along the south-western edge to upwards of 350 feet in North Warwickshire and the parts of Northamptonshire adjoining, all this agreeing with the original increment of submergence in Stage II. He then showed, from evidence afforded by the Yare and Gipping valleys, that this ice, ceasing to advance in East Anglia, shrunk into the valleys of that district, exposing the moraine it had previously laid down to the growth of vegetation, and issued only through these valleys to the sea. The Hoxne palæolithic brickearth he regards as the deposit of a lagoon produced from the interception of the drainage of this surface by the glacier-tongue thus passing through the Waveney valley. The Brandon palæolithic brickearth he regards as connected with the same state of things.

In *Stage* IV. he described the plateau and cannon-shot gravels of Norfolk as resulting from the washing out of the morainic clay by the melting of this ice, which, though shrunken into the valleys of the East of Norfolk, still lay high and in mass in West Norfolk; and showed that, by having regard to the different inclination of the land thus traced, the position of this gravel is reconcilable in no other way. The cannon-shot part of it he attributed to the torrents pouring from this high-lying ice over the west side of the Wensum valley; and the plateau gravels to the deposition of other parts of the same spoil carried into East Norfolk at the commencement of the process and while the ice had not thawed out of the valleys, this gravel afterwards, as the valley-ice thawed, being deposited in them. He also traced the excavation of the trough occupied by the Bain and Steeping rivers in Lincolnshire to the same cause. The finer or sandy part of this material has an extensive spread in South-west Norfolk, forming thick beds; and in a thinner form spreads over North-west Suffolk, where it wraps the denuded edges of the Hoxne and Brandon palæolithic brickearths.

In *Stage* V. he traced the line of gravels that overlie the Chalky Clay where this clay entered the sea. This entry to the sea over the Severn drainage-system took place by way of the watershed between the Welland and Avon, and by the valley of the latter. Its entry into the sea over the Thames system was by way of the watershed between this system and that of the great Ouse in South Bucks, as well as by the valley of the Colne, Lea, and Roding, and over the lower part of the watershed in South-east Essex. Its entry into the North Sea was by the valleys of the Blackwater, Gipping, and other Essex and Suffolk valleys, the entry by the Yare and Waveney being far out beyond the present coast-line. He also traced, by similar evidence, the extent to which the sea entered the Trent system after the ice vacated it. This line of gravel (after allowing for the case that the level of the junction of the gravel beneath the clay represents that of the sea-bottom, while that over the clay more nearly represents that of the sea-top), he showed to correspond with that of the junction of the gravel beneath the clay so far as this is not destroyed in the parts where the ice did not shrink into the valleys; and it also agrees with this line, supplemented by the amount of rise in the interval where the ice did so shrink. Along the south-western edge of the clay this line of gravel, subsequent to the clay, falls from near 400 feet in Bucks to 150 feet in South Essex; from whence northwards along the south-eastern edge it falls uniformly to Ordnance datum in central East Suffolk, and probably continued to fall to 100 feet or so below this at the extreme point where the ice from the Yare valley entered the North Sea far beyond the present coast. Along the north-western edge of the formation this line falls northwards in a corresponding way to that on the south-eastern edge, save that, starting there from near 350 feet, it does not fall below, if even quite down to Ordnance datum near the Wash. He then traced the extent to which the sea on the west, deepening in that direction in accordance with the original depression of Stage II., entered the valleys of the area covered by the ice of the Chalky Clay as this vacated it; the carrying out through the Welland and Avon valleys of the red and white chalk spoil of the Bain-Steeping trough, and its deposition in the Cotteswold gravel up to a high level, coming from the Avon system over the Gloucestershire water-parting into the valley of the Evenlode, a part of the Thames system.

All river-gravels north of the point where the line of gravel over the clay sinks below Ordnance datum, he regards as concealed below the alluvium, and at depths proportional to the fall of that line. Examining in detail the grounds for the contrary opinion heretofore held by himself and by geologists in general, that the great submergence succeeded the principal glaciation of England, he rejected that opinion; and no longer regarding the basement clay of Holderness (with its ancient molluscan facies) as identical with the Chalky Clay, but as moraine synchronous with the Till of Cromer, he considered the gravels with shells at extreme elevations in Lancashire to have preceded all glacial clays but these, and to have escaped destruction by the advance of the ice during the rise only at the south end of the western slope of the Pennine chain, those on the eastern having been wholly swept away; but that gravels were deposited on the east side of the Pennine after the dissolution of the Chalky-clay ice up to the reduced height of the sea-level at that time, and so far as the ice of the purple clay allowed the sea to come. He then relinquished the opinion formerly held by him that the passage of the Shap blocks was due to floating-ice, and referred this to the land-ice crossing the Pennine chain consequent upon greater snow interception from the progress of the rise; and to the same cause he referred the drift which rises high on the eastern slope of the Pennine ridge north of the Aire. To this crossing of the ice having diverted first a part and then the whole of the ice supply of the Chalky-clay glacier, he attributed first the shrinking of that glacier into the valleys in East Anglia, and afterwards its dissolution by the agencies always rife in the Greenland ice (but which are there balanced by continual reinforcement), when by this diversion its reinforcement by ice from the Pennine chain ceased. The purple clay of Holderness, being thus in its lowest part in Holderness coeval with the valley-formed portion of the Chalky Clay of Norfolk and Suffolk (or "third Boulder-clay" of Harmer), was the moraine of this invading ice, which, after crossing at Stainmoor, divided against the eastern moorlands of Yorkshire; and one branch going north of these moorlands through the valley of the Tees, sent off an arm down their eastern flank, the moraine from which is the narrow belt of purple clay which skirts the Yorkshire coast north of Holderness, and spreads out wider in Holderness. This arm in consequence of the Chalky-clay ice not having (from the westerly increment of depression) descended the eastern slope of the Wolds, found sea there covering the basement clay of Holderness, in which sea it stopped between the Humber and the Wash, by means of which the lower part of the purple clay up to the level of about 150 feet, contains intercalated in it beds of sand and gravel, and contains shells and shell-fragments, as does the Lancashire clay similarly extruded beneath the sea. The other branch came south along the western flank of the east moorlands and through the Vale of York, where it ended, and became stationary in the sea as this entered the Trent system on the final dissolution of the chalky-clay glacier.

The author discovers no trace of anything like the intercalation of warm periods up to the stage with which he concludes this part of his memoir; and leaves the description of the later beds, as well as an examination how far arboreal vegetation and the coexistence of Pachyderms and Proboscideans can be reconciled with the contiguity of extensive land-ice, for the concluding part of it.

Geological Society of France.—This important body celebrated its 50th Anniversary on April 1st, 1880, in the apartments of the Society, 184, Boulevard St.-Germain, Paris. The chair was taken by Prof. A. Daubrée, Memb. Inst., Inspector-General of Mines, last year's President. An elaborate report was read by M. de Lapparent, this year's President of the Society, reviewing the labours of the Society since its foundation.

Mr. Thomas Davidson, F.R.S., F.G.S., attended the meeting as the English delegate, being accredited to represent the chief learned societies of this country. As one of the oldest members of the French Society, and a former resident in Paris, where his scientific labours are well known and highly appreciated, Mr. Davidson met with a most cordial and enthusiastic reception. He delivered a congratulatory speech in French. Prof. L. G. de Koninck (Belgium), Sig. Capellini (Italy), Sig. Vilanova (Spain), Prof. Mojsisovics (Austria), etc., also addressed the meeting. The proceedings concluded by a banquet at the Hotel Continental, at 7 p.m., at which eighty members and delegates were present.

Geologists' Association.—Upwards of 100 members and guests of this flourishing Society assembled, at the St. James's Restaurant, on March 4th, 1880, to celebrate by a Memorial Dinner "the coming of age" of the Association. The chair was occupied by the President, Prof. T. Rupert Jones, F.R.S., F.G.S., supported by the Rev. T. Wiltshire, M.A., F.G.S., Prof. John Morris, M.A., F.G.S., R. Etheridge, F.R.S., Pres. Geol. Soc., Dr. Hyde Clarke, Prof. Owen, C.B., M.D., D.C.L., LL.D., etc., Rev. Prof. Bonney, F.R.S., Capt. C. C. King, R.M.A., Mr. J. S. Gardner, F.G.S., Dr. E. B. Tylor, F.R.S., Pres. Anthrop. Inst., W. Carruthers, F.R.S., F.G.S., Henry Woodward, LL.D., F.R.S., Wilfrid H. Hudleston, F.G.S., Dr. J. Foulerton, F.R.S.E., F.G.S., J. Logan Lobley, F.G.S., and other leading geologists.

In proposing "The Geologists' Association and its Founders," the President gave an admirable sketch of the origin, rise, and development of the Association, and of the work it had carried on.

Few Societies have had a brighter career or have done more solid work in twenty-one years than this Association.

The Rev. T. Wiltshire, one of the Founders who was present, referred to the advantage derived by the accession of the members of the Palæontographical Society in its early days. Profs. Owen, Morris, Bonney, Messrs. Etheridge, John Jones, Carruthers, Tylor, Lobley, and others responded.

Geologists' Association.—Easter Excursion.—A most successful excursion of the Geologists' Association took place on March 29th and 30th, to Bournemouth, Christchurch, and Lymington, to study the Eocene Tertiary plant and shell-beds along the coast, under the able guidance of Mr. J. S. Gardner, F.G.S. The entire series of beds from Poole Harbour to Lymington was examined, and numerous points of geological interest studied in detail. The weather proved most propitious.

CORRESPONDENCE.

PROF. J. MILNE ON THE DISTRIBUTION OF VOLCANOS.

Sir,—We are fortunate in having Prof. Milne residing near the volcanic band of the Pacific coast, and shall no doubt have our knowledge of vulcanology advanced by his studies. There is cogency in the reasons which he adduces, to explain the occurrence of vents along the steep margins of oceans, through the thickening of the crust by the cooling effect of the water. He tells us that, "without entering into any calculations on the subject, it is not at all unlikely that, as in one case we have land cooling beneath an atmosphere and the compensating effects of a sun, whilst in the other case we have land cooling beneath water, which, from all we know about deep-sea temperatures, is usually very cold, we should find any given isotherm at a much greater depth beneath the rocks, which form the bed of an ocean, as compared with the depth at which we find it beneath the rocks which form the land."

But why not "enter into calculation," when, as in the present case, that is so easy, and add what this "much greater depth" will be?

Say that the mean temperature of England is 50° Fahr. And suppose the temperature of the sea-bottom to be 32°. The difference is 18°. Then, allowing an increase near the surface of one degree for every 50 or 60 feet of descent, the melting temperature of rock (whatever that may be) will be reached 18 times 50 or 60 feet lower beneath the ocean-bottom, than beneath England. This will make the crust only from 900 to 1080 feet thicker beneath the sea-bottom. But the melting temperature will be reached actually nearer to the solid surface beneath the sea-bottom, than beneath dry ground, which, as in parts of Siberia, is perpetually frozen.

I cannot help suspecting that Professor Milne had in his mind a greater difference than the above, when he used the words "much greater depth." And I am sure that to geologists in general, whose ideas of time and space are formed upon a vast scale, these words would convey a much larger meaning than the modest fact.

It is really time that scientific men and excellent geologists, like my friend Mr. S. V. Wood, jun., should cease to quote with approval such an unphilosophic saying as that "figures may be made to prove anything." Figures do but carry out to its legitimate conclusion some foregone assumption. If the result be wrong, not the figures, but the assumption is in fault. For instance, if there is any error in the result of the abstruse calculation which I have indicated above, it lies, not in the application of the multiplication table, but in the assumption that the temperature of the ground beneath land and sea alike increases near the surface by one degree Fahr. for every fifty or sixty feet of descent.

If this assumption is doubted, I think I have shown why it is correct, in the Phil. Mag. for June 1879, p. 382. O. Fisher.

Harlton, Cambridge, 10*th April*, 1880.

THE GLACIAL DEPOSITS OF CROMER.

Sir,—Knowing the great objection that geologists have to long papers, at least to those of other people, I tried in my account of the Glacial Deposits of Cromer[1] to condense into eleven pages the main results of four years' work, and of several thousand notes. I am afraid that in so doing I have omitted to make sufficiently clear my reasons for arriving at conclusions very different from those of previous observers.

I must thank Mr. O. Fisher for his courteous and unbiassed references to my paper, and observe that others also have drawn my attention to the insufficient explanation given of the supposed action of the ice-sheet.

The thick mass of contorted beds near Cromer I consider to be quite a local phenomenon, as will be seen by my paper, and I think Mr. S. V. Wood, jun., is quite unjustified in trying to saddle me with the absurd theory that the "ice has shoved Norfolk out of its place." I stated that "the mound of contorted beds pushed up by the ice still remains and forms the high land near Cromer."

The contortions near Norwich, in the Waveney Valley, etc., were, I think, formed by the sliding of the ice over the beds, or perhaps ploughed up on the first advance of the ice-sheet. The mound at Cromer seems to have been pushed along by the ice from the N.E., till the mass of contorted beds reached such a thickness as, for a time at least, to entirely stop the flow, and allow the smaller flow from the chalk hills to follow the slope of the ground independently of the larger sheet. The Contorted Drift is beds of any age contorted at the time of the formation of the Chalky Boulder-clay, and I ought to have given a distinct name to the probably sedimentary and slightly contorted Boulder-clay also called "Contorted Drift;" but from the way that any bed may pass laterally into Contorted Drift, I found it in practice often difficult to separate them.

My difficulties in accepting Mr. Fisher's view, that the contortions were formed by the dead weight of masses let down from above, are firstly—that I cannot find a single case where uncontorted beds have been deposited over the contorted ones, though at first sight many sections have that appearance; and, secondly, that no weight we can imagine possible could drive up the solid chalk at Trimmingham in a ridge three-quarters of a mile long from N.W. to S.E., and apparently about 250 yards wide, this disturbance, it must be remembered, affecting not merely the chalk, but 200 feet of overlying clays and sands. It was from observing this and similar ridges that I came to the conclusion that the contortions must have been formed by slow, steady, lateral pressure from the N.E. On first examining the coast, the impression given by the contortions is, that they are hopelessly confused; but after two years' work at the sections and maps, I found that they resolved themselves roughly into a series of folds with the longer axes parallel with the coast.

With regard to the curious hollows in the Trimmingham chalk mentioned by Mr. Fisher, I have examined several, and they seem

[1] Geol. Mag. Dec. II. Vol. VII. p. 55.

to be owing to the sharp folding of the chalk, causing irregular cavities to open in various places, these cavities being subsequently either filled with material from above, which would naturally be stratified, as is often the case with cave deposits, or, as in one instance that I examined, apparently always empty. The folding of the chalk shown in my woodcut can now be easily examined; but in 1868, as shown by Mr. Fisher, the beach was much higher.

The diagram, Fig. 4, of my paper, was only intended to give a general idea of my theory: of course in practice soft beds would take much more complicated folds, though their general direction is still distinctly traceable. Unfortunately, there are only short sections to be seen at right angles to the folds.

The extreme shallowness of the North Sea is such that ice even 250 feet thick would be more than sufficient to dam out all the water in the southern part, and supposing a submergence of 200 feet at the time of the Chalky Boulder-clay, about 500 feet of ice would do the same. At the same time the beds immediately below both the Till and the Chalky Boulder-clay are fresh-water and not marine. Nowhere in the south or east of England have I been able to obtain evidence of a contemporaneous marine fauna in any Boulder-clay. With regard to the so-called "Great Submergence," East Anglia has at present yielded no trace of it; and if it had affected this district, one would naturally expect to find remains of deep-water deposits in such a flat country. CLEMENT REID.

THE TERM "SCHIST."

SIR,—The question raised by Dr. Callaway in the last number of the GEOLOGICAL MAGAZINE will doubtless elicit many answers embodying various shades of opinion. Be these opinions what they may, the word *Schist* has in one respect a definite signification in common with the word *schism*.

A schism is a split of some kind, it may be large or small. A fault is a schism; a joint-plane is a schism; cleavage is schismatic, and foliation and lamination also give rise to schismatic or schistose tendencies in the rocks in which they occur. I think, therefore, that Mr. Allport is perfectly justified in using the adjectives *schistose* and *fissile* synonymously.

The only restriction which long usage appears to have imposed upon the term "schist" is that, whether a foliated or a laminated rock, the planes of fission (if planes they can be called, for they are often small and irregular surfaces of parting) should coincide either with the direction of lamination or with that of foliation. Foliation and lamination are not always coincident.

It seems no reason that because the chief foliated rocks are spoken of as "crystalline schists" that therefore, no other rock, no matter how fissile, should be excluded from the benefit of a term to which its structure may quite well entitle it.

To express my own opinion, I should say that I fail to appreciate Jukes's definition, and that in common with Mr. Allport I use *schistose* and *fissile* as convertible terms when the fission is not of that perfect kind which characterizes slates and shales. I would, therefore, restrict the term "schistose" to an imperfect or irregularly fissile structure. In this respect I take it that a schist differs from a shale. The definitions of such closely-allied terms must, however, depend upon preponderance of evidence concerning the special and distinct senses in which they have been employed. Their correct application, therefore, is essentially based upon usage.

FRANK RUTLEY.

LINNARSSON'S RECENT DISCOVERIES IN SWEDEN.

SIR,—I have to thank Messrs. Linnarsson and Nathorst, of the Swedish Geological Survey, for kindly suggesting the following corrections of my paper on "Linnarsson's Recent Discoveries in Sweden," as published in the January and February parts of the GEOLOGICAL MAGAZINE for the present year.

Page 34, line 35. For *Murchisoni*-bed read *Phyllograptus* Zone.

Page 35, line 28, etc. *Retiolites* Beds. This term is restricted by the Swedish geologists to the strata denominated by myself the Zone of *Cyrtograptus Murchisoni*.

Page 36, line 9. *For* highest *Silurian* strata in Scania, *read* highest *Graptolitic* strata in Scania.

Page 68, line 6 from bottom. *For* regarded as distinct *read* regarded as identical.

Page 70, line 15. Dr. Nathorst was not responsible for the original reference of *Conocoryphe exsulans*, Linnars., to *Cono. coronatus*, Barr. He merely adopted the identification previously made by Messrs. Lundgren and Linnarsson (Geol. Fören. Förhand. 1876, Band iii. No. 9, p. 3, note).

CHAS. LAPWORTH.

ST. ANDREWS, *April* 19*th*, 1880.

THE MICROSCOPIC STRUCTURE OF ATELEOCYSTITES.[1]

SIR,—I have examined by vertical and horizontal sections the shells of *Ateleocystites*, of *Marsupiocrinites*, and of the Trilobite (*Calymene*), all from the Wenlock Limestone, Dudley, which you sent me. That of *Ateleocystites* does not show under the microscope the normal calcareous network which is so fairly constant in the Echinodermata; but the undoubted Echinoderm, *Marsupiocrinites*, was identical in all respects with the former genus. This I attribute to extreme metamorphic action. However, one must not lose sight of the fact that the network structure might, even in the living animal, have been disguised by its interstices being filled with carbonate of lime, a condition often found where there is friction between parts (*e.g.* between head of spine and tubercle, etc.), and to a certain extent probably in old parts (*e.g.* the basals of old Pentacrinites). The Trilobite showed the ordinary tubular structure found in the thicker-shelled Crustacea. It is evident, from the above, that *the apparent absence* of the calcareous network in *Ateleocystites* does not invalidate its being an Echinoderm.

C. STEWART.

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ALBERT EMBANKMENT, LONDON, S.E., *April* 23*rd*, 1880.

[1] This note was unfortunately received by the Editor too late for insertion at p. 200 *ante*, where it should have appeared.

ERRATUM—In Dr. Callaway's letter, April, 1880, p. 188, last line, for *as* read *us*.

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No. VI.—JUNE, 1880.

ORIGINAL ARTICLES.

I.—Contributions to the Palæontology of the Yorkshire Oolites.

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

Introduction.

THE Limestones of the Yorkshire Oolites long ago attracted the attention of collectors from the remarkable beauty of some of the fossils which are preserved in them. We need hardly go back so far as the days of Lister and his *lapides Judaici,* but the Scarborough Catalogue, published in 1816, may arrest our attention for a moment.

It professes to be a descriptive catalogue of the "minerals and extraneous fossils of Scarborough and its vicinity," and was published by subscription. The list of subscribers is an interesting memorial, especially valuable to those acquainted with the neighbourhood, presenting as it does a permanent record of those persons who took an interest some sixty-five years ago in such curious products of the earth. As may be supposed, there are many names in this list well known in East Yorkshire, but amongst the few strangers we read that James Sowerby of London is debited with two copies. The second part of the publication is devoted to fossil conchology, and there are two or three plates containing some very recognizable

Frontispiece to the Scarborough Catalogue.

figures, showing that collections were by no means deficient in good specimens, the neighbourhood of Malton then, as subsequently, furnishing a considerable proportion. The frontispiece, intended to represent part of a *Glyphea*, so common in the Lower Calcareous Grit of Appleton, is, perhaps, one of the quaintest figures in any palæontological work of the present century, but in the other figures there is nothing grotesque whatever.

The attention of Sowerby, who was at that time bringing out the Mineral Conchology, seems to have been drawn by this work to the Oolitic fossils of East Yorkshire, as we find the Scarborough Catalogue mentioned in vol. ii. p. 123, with reference to the so-called *Unio Listeri*, and again, in vol. iii. p. 45, where Sowerby describes *Mya? literata* from a Yorkshire specimen, and refers to the figure in the Scarborough Catalogue (t. ii. fig. 1), which is certainly much better than his own. From time to time Sowerby continued to figure and describe fossils from the Yorkshire Oolites, which have thus contributed a certain proportion of his types.

In the year 1822 appeared the first edition of Young and Bird's Geology of the Yorkshire Coast, which was the second serious attempt to describe and figure a portion of the Jurassic fossils of East Yorkshire, but on a far more extensive scale than in the Scarborough Catalogue. The figures of these authors are, perhaps, better than their names and descriptions, as they were far too much disposed to refer the specimens to existing genera, and had little idea of geological sequence. Their criticisms of some parts of Mr. Sowerby's work drew down the indignation of his relative, who observed, Min. Conch. vol. iv. p. 146, that "the late Mr. Sowerby's veracity and credit needed no defence against the attacks and false surmises of the arrogant." This arose out of a squabble about the identification of some Ammonites. Previously, viz. at p. 112, Sowerby had complained that these authors improperly confounded *Plagiostoma rigidum* with a totally distinct species from Malton, which he named *P. læviusculum*, and also that they "indulged themselves in changing names, and several other liberties too palpably induced by error to merit particular notice."

On the whole, Young and Bird's work is interesting rather than valuable in a palæontological sense; their figures are recognizable and even characteristic in many instances, so that rather than give a new name, it would be preferable to take one from them. In their second edition (1828), unfortunately, some of the guesses of the first edition are reversed, and the same shell is placed under another genus, and with a fresh specific name. Additional fossils are figured, and the original figures, in some cases, by no means improved.

Such was the state of mineral conchology in East Yorkshire—palæontology it could hardly be called—when Phillips appeared on the scene in 1829, and applied the principles of geological science to the fine mass of material which was waiting for some master-hand to reduce it to order. That he was most successful none will deny, and the editions of his Geology of Yorkshire of 1829 and 1835 must be deemed a wonderful step in advance of anything that had been done before. Phillips, however, had not the local knowledge of Young and Bird, any more than they had his philosophy and erudition, but the most awkward feature in his book is that he gives no description of the new species which are figured in the plates. Now the best plate in the world without a description is inadequate, and Phillips's figures are far from being good. The somewhat quaint drawings of the artist, Bird, are, in some cases, more recognizable. Owing to this want of description there has always been a difficulty about Phillipsian species, and some of the identifications, both at home and abroad, have not always been successful. Thus the fossils collected with so much assiduity by Williamson, Bean, and others, from which, for the most part, his types were taken, have not in all instances had full justice done to them.

Meantime the science of palæontology began to make rapid strides, and its cultivation, as regards the fossil mollusca especially, yielded abundant fruit in some of the monographs of the Palæontographical Society, and in many important works on the Continent. Nevertheless, during the period which elapsed between the issue of the second edition of the Geology of the Yorkshire Coast in 1835 and that of the third edition in 1875 no very marked additions were made by publication to our knowledge of the Molluscan fauna of the Yorkshire Oolites, if we except a few plates (with descriptions) devoted to Yorkshire shells in Morris and Lycett's well-known work, and a certain proportion of the species figured and described by the latter author in his Supplement. There is also a paper by Mr. Leckenby on the fossils of the Kelloway Rock, published in the Quart. Journ. Geol. Soc., vol. xv. p. 4. Still the collecting of specimens had been going on steadily all the time, and Sir Charles Strickland, Mr. Leckenby, and Mr. Reed, of York, were pre-eminent in this respect. Important additions too had been made to our knowledge of the geology of East Yorkshire, and altogether a considerable addition of fresh matter was available for the third edition of Phillips's work.

It was, therefore, with no little disappointment that the geological public saw the same old figures reproduced without any description, though occasionally under a new name.[1] In many respects, more especially as a volume of reference, this third edition is most valuable, but as a palæontological work it cannot be deemed satisfactory, considering the date of its appearance. Few will be disposed to doubt, therefore, that many of the fossils of these beds, more especially of the Corallian rocks, which have been especially neglected, require to be refigured, with an adequate description, so that they may be recognized both at home and abroad. To do this without making a tolerably complete monograph of each sectional division would be to neglect a great opportunity. It is therefore proposed to take certain sections, grouped as a matter of convenience, and not necessarily in biological order or in geological sequence. Many considerations have disposed me to begin with a portion, at

[1] The references in the edition of 1875 are materially improved, and for this we have to thank the Editor of this almost posthumous work.—W.H.H.

least, of the Corallian fossils. For some years I have had a tolerable acquaintance with the rich stores of these fossils in the museums at York and Cambridge. There is the Bean collection, too, at the British Museum. I have myself a fair collection, but, above all, Sir Charles Strickland has been kind enough to place at my disposal such specimens as may be required from his own collection. This last privilege is, indeed, most valuable, for, to say nothing of the excellence and variety of many of his specimens, Sir Charles has been careful in almost every case to note the locality, and no one can vie with him in the art of developing a fossil out of a difficult matrix.

Under these circumstances it has been determined to commence with the Corallian Gasteropoda. The principle upon which I would proceed is never to make a new species if it can possibly be avoided, but to endeavour where necessary to clear up doubts regarding species imperfectly figured and described, or else to figure Yorkshire specimens of species which have been described elsewhere. All specimens whose locality is doubtful will be excluded, nor do I bind myself in any way to produce an exhaustive list, or to figure every species. Still less do I undertake to define what a "species" is, as this would raise questions entirely foreign to the scope of the present article, though I am fully aware that what Professor Marsh[1] calls the third period in palæontology has long since come to an end.

To simplify, rather than to multiply, should now be the object of the fossil conchologist, but always with a due regard to persistent variety of form. In this way we shall be able to correlate our Yorkshire beds more closely with those of the rest of England and of neighbouring countries, and thus add a stone to the pile of trustworthy information, which, if less interesting as a mode of dealing with the subject than the problems of speculative geology, may serve to form a sure foundation for legitimate deduction in the future.

No. 1. *Corallian Gasteropoda.*

The details with regard to geological position and localities of the species described are to be found in the "Corallian Rocks of England," by Blake and Hudleston,[2] in the "Yorkshire Oolites" (Part ii. sections 1 and 2),[3] and in Mr. Fox-Strangways' Memoir in Explanation of Quarter-sheets 95 S.W. and 95 S.E., just published.

In Part ii. section 2, of the Yorkshire Oolites, there is a full table of the Corallian fossils of Yorkshire, together with a chapter on the palæontology. The scheme of the Corallian series in Yorkshire may be gathered from the accompanying table (pp. 246-247), extracted from the last-mentioned publication. The general geological features of the district are so well known from the writings of Phillips and others, that nothing further need be said on this subject.

[1] Address before the American Association for the Advancement of Science, 1879.
[2] Quart. Journ. Geol. Soc. 1877, vol. xxxiii. p. 317.
[3] Proc. Geol. Assoc. 1876, vol. iv. p. 353, and 1878, vol. v. p. 407.

The first question we should ask ourselves is, what are the relations of the Corallian Gasteropoda to the general fauna of the formation? and secondly, but more especially, what are its relations as a group, to the fauna of analogous beds above and below? The first part of the question is easily disposed of, as a reference to the table of fossils will show the relative proportions of Gasteropods to Lamellibranchs, etc., whilst it may also be noted how rare the former are in the lower beds, and how, as the calcareous deposits begin to predominate, the Gasteropods increase in numbers both individually and specifically. It is worthy of remark that an abundance of Gasteropods is not always the accompaniment of a coralline facies, as is proved by their extreme rarity in the Lower Coral Rag of Hackness.

The second part of the question opens up an interesting field for speculation as to whence the "species" were derived. To those who know the present insulated position of the Yorkshire Corallian area this is a subject of considerable difficulty. This insulation is both lateral and vertical. The lateral insulation on the west and north is to a certain extent, though we cannot say how far, due to denudation along the outcrops. On the south the insulation must be ascribed, in our present state of knowledge, to non-deposition, whilst on the S.E. the formation passes under higher beds, and is then lost to view, though there are some reasons for thinking that the formation gets thinner in this direction.

In a vertical direction its insulation is still more complete. Thus when we regard the formations which immediately preceded those beds in time within the area, we find a considerable thickness of clay, with few or no univalves. This clay gradually becomes more sandy, and finally passes, in most instances without any marked petrological break, into the Lower Calcareous Grit, which may be regarded as the foundation of the Corallian beds, and as the connecting link with the Oxfordian, of which a considerable portion of these beds in Yorkshire may be considered as an exceptional development. A reference to the table of fossils will show that there are but few Gasteropods in the Lr. Calc. Grit, even in the Lower Corallian Limestones, which are included in the same column. This may be capable of two explanations, firstly, that the conditions were not favourable; secondly, that, having been driven away by "Oxford Clay" conditions, they had not had time to re-occupy the ground. This latter view seems to me by far the most probable, though it may well be that the conditions became more favourable for Gasteropods as the Corallian accumulations increased.

Most geologists are aware that the so-called Yorkshire Oolites consist of great masses of sandy and argillaceous sediment, in part estuarine, and, as a rule, poorly furnished with fossils; but that on certain horizons there are rich shell-beds of limited vertical extent, which give us passing glimpses, as it were, of the fauna of the period. Such are the Dogger, Millepore Bed, Scarborough Limestone, Cornbrash, and shell-bed at the top of the Kelloway Rock. It will therefore be an interesting subject for inquiry as to the

GENERALIZED SCHEME OF CORALLIAN

FORMATION.	TOPOGRAPHICAL DIVISIONS AND VARIETIES.	LOCALITIES.
A. SUPRACORALLINE. 15-40 ft., wanting in places.	1. Upper Calcareous Grit flanking the western part of the Vale of Pickering. 2. Argillo - calcareous beds (Throstler) of the same locality. 3. Argillo - calcareous beds (Cement) stones) of the Howardian Hills.	Pickering, Kirkby Moorside, Helmsley, Oswaldkirk. Pickering, Appleton Common, near Kirkby Moorside. Hildenley, Burdale, Langton.
B. CORAL RAG, subzone of *Cidaris florigemma*. 12-40 ft.	1. Rag of the Scarborough district, without *Cidaris florigemma*. 2. *Florigemma*-Rag flanking the western part of the Vale of Pickering, on both sides. 3. *Florigemma*-Rag of Langton Wold.	Ayton, Brompton, Hackness. Sinnington, near Kirkby Moorside, Helmsley, Oswaldkirk, Slingsby. Hildenley, Langton Wold, North Grimston.
C. CORALLINE OOLITE. 20-35 ft.	1. Oolites underlying the Rag of the Scarborough district. 2. *Chemnitzia*-limestones, compact or suboolitic; impure earthy limestones. *Trigonia*-beds at base. 3. Oolites of the Howardian Hills in part.	Seamer, Forge Valley, Brompton Keld. Pickering, Kirkdale, Sproxton, Ampleforth Beacon. Malton, Settrington.
C[1]. MIDDLE CALCAREOUS GRIT. 10-45 ft.	The *Trigonia*-beds at the top of this series in the Pickering district are referred palæontologically to the Coralline Oolite.	Filey Brigg, Pickering, Duncombe Park, Wass Moor. Not proved in the Howardian Hills.
D. LOWER LIMESTONES. 20-120 ft. N.B.—The above figures do not represent the absolute *maxima* and *minima* of each formation.	*Upper Division.* 1. Oolites underlying the M.C.Grit of the Tabular Hills. 2. Oolites, sometimes split by a fourth grit, of the Hambleton Hills. 3. Oolites of the Howardian Hills in part. *Lower Division.* 1. Passage-Beds at base of the Lower Oolite in the eastern districts. 2. Cherty Limestones of the Western districts. 3. Basement Limestones above the L.C.Grit of the Howardian Hills.	Scarborough Castle, Lime quarries of Silpho and Suffield. Forge Valley, Thornton, Cropton. Hawnby Hill top, Kepwick, Cold Kirkby, above Rievaulx. Broughton, Swinton. Scarborough Castle, Hackness (Lower Coral Rag), Filey Brigg, Wydale. . . . . Appleton, Brows quarry (Malton)
E. LOWER CALCAREOUS GRIT proper.		

Limestones and Associated Beds.

Lithology—Remarks.		Some of the Characteristic Fossils.
Reddish Calc Grits, often cherty, with sometimes marly shales. Dirty earthy Limestones, very unfossiliferous. Hard calcareous bands and soft sub-calcareous Shales.		*Belemnites nitidus*, Dollf. *Am. varicostatus*, Buckl. *A. alternans*, Von Buch. *Ostrea bullata*, Sow. *Gryphæa subgibossa*, Bl. & H. *Pecten Midas*, D'Orb. *Modiola cancellata*, Röm. *Lucina aspera*, Buvig. *L. substriata*, Röm. *Thracia depressa*, Phil. *Goniomya*, *Pleuromya*, *etc.*
Boulders of *Thamnastræa concinna*, and branches of *Rhabdophyllia* in an intercoralline brash. Variety of Corals; often massive, sometimes compact and cherty, rarely oolitic. Compact Limestones; massive Coral Bands, shelly brash, rarely oolitic. Fine white Oolites, with Coral-shell Beds in the upper part. Usually compact creamy Limestones with sparry Shells, calcareous Pastes with Oolitic granules. Clean white Oolites, sometimes a little marly, burnt for lime. An Arenaceous Calc Grit, sometimes with Shell-beds, where it graduates into the overlying series. Building.	*Zone of A. plicatilis.*	*Am. varicostatus* (Buckl.) var. of *A. plicatilis*. *Purpuroidea nodulata*, Y. and B. *Natica maxima*, Y. and B. *Cerithium limæforme*, Rœm. *Nerinæa Rœmeri*, Goldf. *Littorina muricata*, Sow. *Turbo funiculatus*, Phil. *Ostræa duriuscula*, Phil. *Pecten vimineus*, Sow. *Lima pectiniformis*, Schlot. *Arca quadrisculata*, Sow. *Astarte rhomboidalis*, Phil. *Opis virdunensis*, Buvig. *Terebratula insignis*, Schübl. *Cidaris Smithii*, Wr. *C. florigemma*, Phil. *Hemicidaris intermedia*, Flem. *Pseudodiadema hemisphæricum*, Ag.—Coral Rag. *Belemnites abbreviatus*, Mill. *A. plicatilis*, Sow. *A. cordatus*, Sow. *Chemnitzia heddingtonensis*, Sow. *Nerinæa visurgis*, auct. *Cerithium muricatum*, Sow. *Pecten intertextus*, Rœm. *Cucullæa corallina*, Damon. *Trigonia Meriani*, Ag. *T. perlata*, Ag. *Lucina aliena*, Phil. *Astarte Duboisiana*, D'Orb. *Pygurus Hausmanni*, K. and D.—Coralline Oolite. N.B.—The top shell-bed of the Lower Limestones is included with the Coralline Oolite palæontologically.
Small-grained Oolites, frequently rather gritty, much used for lime. Gritty small-grained Oolites, often very impure, quarried for lime and roadstone. Thick-bedded Oolites, formerly much burnt for lime. Coarse gritty Limestones, often ferruginous. The basement beds not well distinguished here. Fig-seedy Limestones, with much grit—building, road stones.	*Upper Part of Zone of A. perarmatus.*	*Belemnites abbreviatus*, Mill. *A. perarmatus*, Sow. *A. cordatus*, Sow. (*excavatus.*) *A. goliathus*, D'Orb. *Cylindrites elongatus*, Phil. *Avicula ovalis*, Phil. *A. expansa*, Phil. *Pecten fibrosus*, Sow. *Gervillia aviculoides*, Sow. *Myacites*, *Pholadomya*. *Echinobrissus scutatus*, Lam. *Holectypus*. *Ammonites Williamsoni*, Phil. *A. goliathus*, D'Orb. *Avicula ovalis*, Phil., and *expansa*, Phil. *Gervillia aviculoides*, Sow. *Trigonia clavellata?* Sow. *T. triquetra*, Von Seeb. *T. Snaintonensis*, Lyc. *Sowerbya triangularis*, Phil. *Waldheimia bucculenta*, Sow. *W. Hudlestoni*, Walk. *Terebratula fileyensis*, Walk. *Rhynch. Thurmanni*, Voltz. *Glyphea rostrata*, Phil. *Millericrinus echinatus*, Goldf. *Spongia floriceps*, Phil.

degree of relationship between the Corallian Gasteropoda and those of the fossiliferous horizons which preceded the Corallian beds within the area. Tables of fossils may guide us to a certain extent, but owing to many causes, more especially to the binomial system of nomenclature, the mere names of fossils afford but little insight into their differences and affinities.

The earliest collectors amassed a heap of curios, and for a long time doubted their organic origin. The second stage of observation was influenced and obscured by certain prejudices, but the third stage witnessed the establishment of the principles of stratigraphical palæontology, though much affected by the prevailing belief—that every species, ancient and modern, was a distinct and separate creation. This belief still lingers in the minds of some, and the unequal value of specific names as a means of differentiation may perhaps tend to foster the idea by increasing the apparent imperfection of the geologic record. Our object, therefore, in dealing with the Corallian Gasteropoda should be, after a careful description of such forms as seem entitled to the denomination of species, to dwell especially upon their distribution and representatives or relatives in other districts or in other beds in the same district. This method may be of service in arriving at an understanding as to the physical conditions and life history of the period, without in any degree conflicting with the more important biological work of other authors.

(*To be continued.*)

II.—The Subdivisions of the Chalk.

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

[Read before the Geological Society of Norwich, Feb. 3rd, 1880; and communicated by permission of the Director-General of the Geological Survey.]

THE earliest attempt to describe the component beds of the English Chalk was made by W. Phillips in 1819: this is his well-known account of the cliffs between Dover and Folkestone, which is reproduced in Conybeare and Phillips' Geology (1822). He recognizes four divisions as follows:—

1. The Chalk, with numerous flints.
2. The Chalk, with few flints.
3. The Chalk, without flints.
4. The Grey Chalk or Chalk Marl.

Samuel Woodward published his Geology of Norfolk in 1833, and his classification is very similar, viz.—

1. Upper Chalk, with many flints.
2. Medial Chalk, with few flints.
3. Lower Chalk, without flints.
4. Chalk Marl.

The extent of ground occupied by each of these divisions is indicated in the geological map, but the boundary-lines are stated to be only approximately correct, and it is evident that they are so. It would therefore be difficult to say how far the divisions proposed by Phillips and Woodward are respectively identical, but it is obvious that the same basis of classification is adopted by both. The arrangement may indeed be regarded as practically a division of the formation into three parts, viz. the Chalk without flints, including the Chalk Marl; the Chalk with few flints; and the Chalk with many flints.

Phillips was content with this terminology, but Woodward went much further, and gave greater distinctness to the divisions by indicating their extent on his map, by recording the fossils found in each, and by proposing a more convenient nomenclature.

Subsequent geologists, however, who described the Chalk in the South of England, Mantell, De la Beche, and Dixon, do not seem to have appreciated the truth conveyed in Woodward's nomenclature, and only recognized two divisions above the Chalk Marl, viz. a Lower Chalk without flints, and an Upper Chalk with flints. This classification, though apparently more simple, is not necessarily more natural, but being adopted by the majority of writers, it finally found its way into Manuals of Geology, and into the publications of the Geological Survey.

Between the Upper and the Lower Chalk, however, no clear line of separation was recognized until 1861, when Mr. Whitaker described a particular bed under the name of Chalk Rock, and indicated its occurrence at the top of the Lower Chalk in the counties of Wilts, Berks, Oxford, and Bucks. He acknowledged, moreover, the occasional presence of flints in the Lower Chalk, and proposed to regard this rock as forming a convenient line of division between the Lower and Upper Chalk.

Mr. C. B. Rose deserves mention as the only geologist who followed in Woodward's steps; he always maintained the expediency of adopting the arrangement into Lower, Medial, and Upper Chalk, and pointed out that in Norfolk certain fossils are characteristic of each division. Mr. Gunn also made a point of this in his Geology of Norfolk (1864).

Until 1870, however, very little was added to our knowledge of the distribution of organic remains in the Chalk. During that year Mr. Caleb Evans published a paper on "Some Sections of Chalk between Croydon and Oxtead"; this was a contribution of much value, because the author had carefully collected the fossils from each set of beds, and was the first to perceive the possibility of a zonal classification for the English Chalk. He establishes six of these subdivisions or zones, and groups them under three headings, viz.—

1. The Chalk, with bands of flint.
2. The Chalk, with bands of Marl.
3. The Grey Chalk and Chalk Marl.

—thus reviving the older tripartite arrangement, supporting it by palæontological facts, and so placing it on a firmer basis.

Dr. Barrois' work, published in 1875, and entitled "Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande," is now well known to all students of the Chalk, and has already been brought before the notice of this Society. I need only observe, therefore, that Dr. Barrois applies to the English Chalk the same zonal classification which has been so carefully worked out in France by Professor Hébert and himself, and that these zones are arranged under the three great sections into which D'Orbigny had originally divided the French Chalk: viz. *Cenomanien, Turonien,* and *Senonien.* It is also clear that these divisions are to some extent correlative with the Lower, Middle, and Upper Chalk of Woodward and Rose.

The result, therefore, of the more careful and detailed observations that have recently been made is to set aside the old divisions depending on the proportions of flint nodules in the Chalk, and to introduce the new element of the zonal distribution of life. It consequently becomes necessary to re-consider the questions of primary subdivision and nomenclature; the latter is involved in the former, and before that can be determined, we must ascertain where the greater palæontological breaks in the series occur, whether they coincide with any beds of marked lithological character, and whether the natural division of the whole formation thus suggested is into two, or three parts.

As the survey of the Cambridgeshire Chalk by Mr. Penning and myself has thrown some light on the points above mentioned, I propose to give a short account of the zonal divisions which we have established in that county; for a full description of these beds and their fossil contents I must refer to the Memoir on the neighbourhood of Cambridge, which will shortly be published.

During the progress of this survey in 1875–77 we recognized the representatives of the two hard bands which had been described by Mr. Whitaker in more southern counties under the name of Chalk Rock and Totternhoe Stone; we furthermore discovered the existence of a third intermediate band of rock, to which we gave the name of the Melbourn Rock; and which proved to be of great stratigraphical importance. These three beds we succeeded in tracing across Cambridgeshire for a distance of about twenty-five miles, and have laid down lines on the Ordnance Map which give a sufficiently accurate indication of the course taken by each outcrop. The result of this is to divide the Chalk into four stages, which are as clearly defined as if they were subdivisions founded on difference of lithological character, like those of the Lower Greensand in the Wealden area.

Between these boundary-lines certain palæontological zones are recognizable, and the distribution of the fossil remains in these confirms the stratigraphical evidence as to the relative importance of the rock beds for the purposes of classification. The following is a brief account of these zonal divisions in Cambridgeshire (see Table on p. 257):—

1. *Cambridge Greensand.*—This is the homotaxial equivalent of what has elsewhere been called the Chloritic Marl, and should without doubt be regarded as the basement bed of the Chalk Marl.[1] This thin noduliferous layer has been so often described that it is hardly needful to give much description of it here; I will only remind you of the following facts,—that the nodules are enclosed in

[1] See Quart. Journ. Geol. Soc. vol. xxxi. p. 272; and Geol. Mag. Decade II. Vol. IV. p. 350.

a matrix of glauconitic marl, which passes up into grey marly chalk, that four-fifths of the fossils found in it have been derived from the Gault, and that the fauna of the bed itself certainly belongs to that of the Chalk Marl.

2. *Chalk Marl or Zone of Rhynchonella Martini.*—This consists of hard greyish marl below, passing up into softer and more argillaceous bluish-grey marl; the whole being about 60 feet thick. It is not very fossiliferous, and only 20 species have yet been collected from it; 14 of these occur also in the Greensand at its base, but *Ammonites varians* and some other species appear for the first time in its upper beds. It is a remarkable fact that *Rhynchonella Martini* has never yet been detected in the Cambridge Greensand, where its place is taken by a variety of the allied species, *Rh. lineolata;* this latter does not seem to occur in the overlying marl, and is only known elsewhere in the Neocomian Clay of Speeton, and the Red Rock of Hunstanton. Another little Brachiopod, found abundantly in the Greensand and also in the Chalk Marl, is a minute variety of *Terebratulina striata*, recently named *T. triangularis* by Mr. Etheridge. This has hitherto been considered a variety of *T. gracilis*, and is in some respects an intermediate form between the two species. I believe the same variety occurs also in the Hunstanton rock.

3. *Totternhoe Stone.*—At the base of this division there appears to be a more or less continuous layer of green-coated calcareo-phosphatic nodules, which were first described by Prof. Hailstone in 1816.[1] The stone above is a compact grey sandy limestone, in beds about 2 or 3 feet thick, and having a total thickness of from 12 to 15 feet. The best exposure to be found in Cambridgeshire is at Burwell, where it is largely quarried for building stone, and where it has yielded a large number of fossils. There is a good collection of Burwell stone fossils in the Woodwardian, and the fauna now known is a large one, numbering from 80 to 90 species.

Mr. Etheridge has described several new forms, and two of these, *Lima echinata* and *Pecten fissicosta* are very characteristic of the horizon; many other fossils are much more common, such as *Rhynchonella Mantelliana*, *Kingena lima*, *Pecten opercularis* and *Lima globosa*, but these occur also in the beds above and below. Cephalopoda and Gasteropoda are here particularly abundant, *Ammonites varians* and *Am. cenomanensis* may be specially mentioned as frequently met with. *Holaster subglobosus* has not yet been found at Burwell, where *Hemiaster Morrisi*, appears to take its place, but the former has been found in the basement bed elsewhere.

4. *Zone of Holaster subglobosus.*—At Burwell the upper limit of the Totternhoe Stone is marked by a bed of hard sandy rock, known locally by the name of "bond," but elsewhere the line of division is not so clear; the chalk, however, quickly becomes less sandy, and of a yellowish or creamy-white colour, passing up into a tough but nearly pure white chalk. In this division the planes of bedding are very indistinct, and the mass splits along curved lines, which produce an appearance of irregular and lenticular bedding. Fossils

[1] Trans. Geol. Soc. vol. iii. p. 243.

are most abundant in its lower portion, which is everywhere characterized by the frequent occurrence of *Holaster subglobosus. Holaster trecensis, Discoidea cylindrica,* and *Ammonites rhothomagensis* may also be mentioned as occurring in this zone, but most of the other fossils range up from the beds below. *Belemnites plenus* only occurs in the topmost bed.

So far we have found a continuous succession without any marked break either in the series of beds or of organic remains. All the fossils of the Chalk Marl range into the Totternhoe Stone, and the number of forms that are confined to the latter will probably be largely diminished by future explorations in the overlying zone, with which it is already known to have many species in common. The three subdivisions may, in fact, be regarded as forming a group of beds characterized by a fauna of one general type, and they are the exact equivalents of the Chalk Marl and Grey Chalk at Folkestone, as defined by Mr. F. G. H. Price.[1]

Dr. Barrois has proposed a similar arrangement for this portion of the series in the South of England; he considers it as forming the "Assise du *Holaster subglobosus*," which he subdivides into four *niveaux* or subsidiary zones; the first is that usually called Chalk Marl, the second (niveau de *Am. varians*) corresponds roughly with our Totternhoe Stone,[2] the third is certainly co-ordinate with the greater part of our *Holaster subglobosus* zone, the upper portion of which may represent Barrois' fourth zone, that of *Belemnites plenus*.

This last zone has a greater development in France, and Dr. Barrois suggests that it has suffered considerable erosion in England, and observes that the basement bed of the Turonien frequently contains rolled fragments of Belemnite. In this he anticipates the conclusion to which I have been led by a study of the Cambridge section, for I have little doubt that at this point in the series there is a distinct stratigraphical and palæontological break, as will appear in the sequel, and is more fully discussed in the Geological Survey Memoir.

5. *Melbourn Rock.*—This rocky belt, or *niveau* as a French geologist would call it, is never more than ten feet thick, but it presents such marked and constant lithological characters as to deserve a distinct local denomination. Excellent sections of it being exposed in two quarries near Melbourn, between Cambridge and Royston, it has been named after that village. It consists of several thin courses of hard yellowish rocky chalk, separated by layers of greyish laminated marl or shale, generally containing numerous nodules or pebbles of hard chalk, to which small Oysters are frequently attached.

Besides this oyster, which is a variety of *Ostrea vesicularis*, crushed *Rhynchonellæ* and rolled *Belemnites* also occur, together with *Inoceramus labiatus* and Fish teeth, *Lamna, Otodus, Saurocephalus,* etc. A

[1] Quart. Journ. Geol. Soc. vol. xxviii. p. 445.

[2] While bearing testimony to the great value and general accuracy of Dr. Barrois' work, I am constrained to point out that he never correctly identified the position of the Totternhoe Stone, having first placed it too high, and afterwards too low in the series.

small round quartz pebble was also found in this stratum at the Shelford pits, near Cambridge.

Dr. Barrois observed the occurrence of a yellow marly band at the top of the Cherry Hinton quarry, and calls it the zone of *Belemnites plena* in a remanié state.[1] I afterwards found that this was the basement bed of the rock so well exposed at Shelford and Melbourn, and that the overlying beds noted by Barrois, and referred to his zone of *Inoceramus labiatus*, were really part of the same rocky band, which I now regard as forming the base of the Turonien or Middle Chalk of Cambridgeshire.

It cannot be regarded as in any sense a palæontological zone, but rather as a line of demarcation between two distinct groups of strata, and separating two different fossil assemblages; nearly all the species found in the Lower Chalk have now disappeared, and only two or three cosmopolitan forms survived to reappear in the beds above, which contain an entirely new assemblage of Brachiopods and Echinoderms.

6. *Zone of Rhynchonella Cuvieri.*—The Chalk of this zone is not often quarried, but the exposures that do occur show it to be very evenly bedded, white, and rather hard; its thickness, including the Melbourn Rock at the base, is about 70 feet. Scattered flints are occasionally found in the upper part of the zone. Its characteristic fossils are *Inoceramus mytiloides* (= *labiatus*) and *Rhynchonella Cuvieri;* Echinoderms are rare, but *Galerites globulus, Cidaris hirudo*, and *C. dissimilis* have been found.

7. *Zone of Terebratulina gracilis.*—At the base of this division there are some layers of grey marl containing small Brachiopods, and some beds of hard compact chalk. Flints occur at certain horizons, but most of them are remarkably elongated and root-like, and are very different from the nodular flints of the Upper Chalk. *Terebratulina gracilis* is everywhere abundant, as is also *Galerites subrotundus*, and *Discoidea Dixoni* is occasionally found; most of the fossils in the zone below range up into this; its full thickness cannot be far short of 100 feet, but its upper limit has not been fixed with any certainty in Cambridgeshire.

8. *Zone of Holaster planus.*—The chalk of this zone is soft and white, and contains regular layers of black flints, some long and narrow, others large and nodular. Its thickness is probably 50 or 60 feet, and its fauna is quite different from that of the zone below; *Holaster planus* makes its appearance, together with a species of *Micraster* (? *breviporus*) and other forms that become common in the Upper Chalk, such as *Cidaris sceptrifera, Cyphosoma radiata* and *Spondylus spinosus.* Ventriculites too are especially abundant in this zone, and serve to distinguish it from the zone below.

9. *Chalk Rock.*—This is really the topmost bed of the zone above described,—the same *Holaster* and *Micraster* are found in it, together with many other fossils which appear to have a similar range, such as *Ammonites Prosperianus.* It is specially characterized by the occurrence of univalves, *Turbo gemmatus* being the commonest.

[1] Recherches sur Terr. Cret. Sup. p. 155.

Ventriculites are also abundant; and there is a new species of *Rhynchonella* (*R. reedensis*), which may be regarded as intermediate between *Rh. Cuvieri* and *Rh. plicatilis.*

The rock consists of hard yellowish semi-crystalline chalk or rather limestone, and there are sometimes two distinct beds separated by a band of soft pulverulent chalk. Its upper surface is clearly defined and occasionally presents the appearance of having suffered erosion. As it is traced northward, however, it appears to lose some of these distinctive characters, and to be represented by one or more layers of hard yellowish chalk, containing only a few of the characteristic fossils: it occurs with this facies in certain quarries along the high ground between Balsham and Newmarket.

10.—*Zone of Micraster cor-bovis.*—Above the Chalk Rock there is soft white chalk with many layers of flints. In this Micrasters are particularly abundant, and some of those found at Balsham are considered by Dr. Wright to belong to *M. cor-bovis,* Forbes, but they are associated with others which greatly resemble the form known as *cor-testudinarium,* and this is undoubtedly the zone in which Dr. Barrois finds the latter to be generally abundant.

The other fossils common here are *Ananchytes ovata, Cidaris sceptrifera, Spondylus spinosus, Rhynchonella plicatilis,* and *Terebratula semiglobosa,* var. *bulla* of Sowerby. Many of the last-mentioned are exceedingly like *T. carnea* of the Norwich Chalk, and they may be regarded as intermediate between *T. semiglobosa* and *T. carnea,* which is an interesting fact when their intermediate position in the geological series is also taken into account.

Beyond this zone our observations did not extend, and the remainder of the Upper Chalk in its extension through Essex is much obscured by the superjacent glacial deposits, but the succession of zones could probably be made out by working along some of the valleys.

The following is a summary of the principal facts concerning the Cambridgeshire Chalk.

1. That the zones of life are similar to those established elsewhere, and have been actually traced over a considerable area.

2. That there are two breaks of more or less importance, marked by the occurrence of the hard rocky beds which are termed the Melbourn Rock and the Chalk Rock.

3. That a middle division of the Chalk is thus marked off, and that its establishment is confirmed by the palæontological evidence.

Many facts in support of the last conclusion are given in the memoir before referred to, and though complete data for a comparison of the three faunas do not yet exist, yet it is quite possible to form an approximate estimate. In making such calculations it is best to consider the Invertebrata only; of these about 80 species have been obtained from the Lower Chalk near Cambridge, and no less than 70 of them appear to have died out before or during the deposition of the Melbourn Rock, only 10 of them having yet been found in the Middle Chalk. Further explorations may result in the discovery of a few more lingerers in the higher beds, but this will not alter the inference which the numbers clearly indicate, viz. that a very important break occurs in the succession of life at this time. Moreover, similar calculations based on the lists of fossils found in other areas by Caleb Evans, Dr. Barrois and F. G. H. Price, strongly confirm this conclusion, for in no case are more than three of the recorded species common to the two assemblages.

The great difference between the two faunas is well illustrated by the amount of specific and even generic change exhibited in certain classes of animals, such as the Echinodermata; thus out of 20 species recorded by these authors as occurring in the Lower Chalk, only *Goniaster mosaicus* and two species of *Cidaris* range up into the Middle Division, whence about an equal number of species have been obtained. The genera *Peltastes, Pseudodiadema, Echinocyphus* and *Hemiaster* do not appear in the newer fauna, while *Cyphosoma, Galerites and Micraster* are absent from the older.

The Ammonites again are represented by different species in these two divisions of the Chalk, only one (*Am. Lewesiensis*) being yet known as occurring above and below the thin band of marl which separates the Turonien from the Cenomanien in the South of England.

It is clear, therefore, that a distinct palæontological break occurs at the horizon above indicated, and that a large number of species became extinct or migrated to other areas. Now such a result may be produced either by a sudden change in the conditions of existence, or by a gradual change effected during a period of time that was unfavourable to deposition. As far as we can tell, the conditions of existence do not seem to have changed very greatly or very suddenly, for the beds of chalk above and below this horizon are not very dissimilar in lithological character, and the differences are hardly sufficient to have caused much alteration in the forms of life: they are not in fact so great as the differences presented by the lower and upper portions of the inferior division itself. We cannot but conclude, therefore, that the break between the two formations marks the lapse of a considerable period of time.

It only remains for me to indicate how far these divisions are likely to be similarly developed in Norfolk; *in limine* I should observe that in proceeding from Cambridge to Norfolk it is probable that we pass from one area of deposition to another; at any rate, the conditions which prevailed in the latter during the earlier stages of the formation were very different from those which obtained in the London Basin. Until therefore we know more of the manner in which one facies of the Lower Chalk passes into the other, no attempted correlation can be more than suggestive, and I only offer the following remarks as a kind of commentary on the record of facts and fossils given by Dr. Barrois (*op. cit.* p. 156, *et seq.*).

In the Hunstanton section it is clear that the zones of the great *assise à Holaster subglobosus* have very diminutive representatives, and I doubt whether the term Chalk Marl is applicable to any of them. There is some probability in Dr. Barrois' suggestion that the "Sponge bed" is the analogue of the so-called Chloritic Marl, because it clearly forms the basement bed of the Lower Chalk. Between this, however, and the overlying bed of grey sandy stone there is a clear line of separation, and the latter is perhaps more likely to be the attenuated representative of the Totternhoe Stone, than of the Chalk Marl. The occurrence of *Ammonites rhothomagensis, Pecten Beaveri, Discoidea cylindrica,* and *Epiaster crassisimus* is at any rate suggestive of a higher horizon than that which is generally characterized by *Plocoscyphia mœandrina,* with which they are here associated.

The succeeding beds, E., F., G., of Barrois, are doubtless homotaxial with the zone of *Holaster subglobosus* when used in its more limited sense, and as I have already defined it.

The remaining 12 or 15 feet at the top of the cliff at Hunstanton are referred by Barrois to his zone *à Belemnites plenus.* This, however, is a somewhat ambiguous term, because he uses it also for the marly layer at Cherry Hinton, which is really the base of the Melbourn Rock, and above the true zone of *Bel. plenus.* It was with the latter, which has a greater development in the north of France, that Barrois probably intended to compare this portion of the Norfolk Chalk.

The Hunstanton section is therefore cut off at a very interesting point, just before the top of the Lower Chalk is reached. Dr. Barrois, however, indicates the outcrop of the overlying zone at Sherborne in these words—"To the north of the village, in the higher part of the quarries, I recognized the hard nodular bed which occurs throughout England towards the base of the zone of *Inoceramus labiatus.*" Can this be the Melbourn Rock? is the comment immediately suggested by this description. The nodular chalk to which Barrois refers as occurring throughout (the south of) England is probably rather above the base of the zone, but it would be very interesting to determine whether the Sherborne bed may not be the actual representative of the Melbourn Rock, because it would then supply the desideratum of a base-line for the middle division of the Chalk in Norfolk.

It is very probable that the hard chalk of Sherborne with *Inoceramus labiatus* and *Rhynchonella Cuvieri* formed part of Woodward's "Lower or Hard Chalk," and that his Medial Chalk was merely intended to signify that portion which contains a few flints, and is intermediate between that without any and that with many flints. The localities given by Woodward appear to be chiefly along a line which would correspond with the outcrop of Barrois' zone of *Holaster planus;* a zone which seems to have a considerable thickness in Norfolk, and to contain grey instead of black flints. Now, however, it has become necessary that the Medial Chalk should receive a more strict definition, and it seems desirable to extend the application of the term rather beyond its original scope, so as to bring the Norfolk divisions into correspondence with those now proposed for the rest of England.

I would therefore suggest that Norfolk geologists should take every opportunity of searching for the representatives of the two rock-beds which are so conspicuous in Cambridgeshire. I have already indicated where the Melbourn Rock may possibly be found; but whether the Chalk Rock is continued northward, with the same characters that it exhibits near Royston and Saffron Walden, is perhaps more doubtful. Still it is quite possible that certain yellowish nodular layers will be found at the top of the *Holaster planus* zone, as is the case near Newmarket, and that these may be taken as the line of division between the Middle and Upper Chalk. There is, indeed, every reason to expect that the higher zones of the formation will eventually be satisfactorily correlated throughout England, France, and Belgium, since the conditions under which they were deposited were certainly more uniform than those which prevailed during the earlier part of the Cretaceous period.

In conclusion I would remind you that the credit of first proposing the tripartite division of the Chalk belongs to the Norfolk geologist—Samuel Woodward. He marked out the broad outlines of what I have little hesitation in calling the true and natural classification, and drew up separate lists of the fossils found in each division. It is astonishing that English geologists should not have pursued the study of the formation on the lines suggested by these early writers, especially as a similar system was being adopted and developed in France; so that it has actually remained for French geologists to demonstrate the applicability of this system to the Chalk of our own country. Much however still remains to be done in completing our knowledge of faunas of the different zones, and every one who makes a collection of fossils from any part of the Chalk, and is careful to record the exact zone and quarry where each specimen was obtained, will be rendering valuable assistance.

Classification of the Chalk.

S. Woodward, 1833. Norfolk.	W. Whitaker, 1865. Bedford and Bucks.	Caleb Evans, 1870-77. Kent and Surrey.	Jukes-Browne, 1880. Cambridgeshire.	
Upper Chalk.	White Chalk with flints.	Riddlesdown Beds.	Zone of *Micraster cor-bovis*.	U. Chalk
	Chalk Rock.		Chalk Rock.	
Medial Chalk with few flints.	White chalk with thin layers of grey marl, and a few flints in upper part.	Kenley Beds. Whiteleaf Beds Upper Marden Park Beds.	Zone of *Holaster planus*. Zone of *Terebratulina gracilis*. Zone of *Rhynchonella Cuvieri*. Melbourn Rock.	Middle Chalk
Lower Chalk without flints.	Hard bedded chalk with thin marly layers. Blocky chalk with curved and irregular bedding. Totternhoe Stone. Totternhoe Marl.	Lower Marden Park Beds. Oxstead Beds.	Zone of *Holaster subglobosus*. Totternhoe Stone. Zone of *Rhynchonella Martini* = Chalk Marl.	Lower Chalk
Chalk Marl.	Chloritic Marl ?.		Cambridge Greensand.	
Red Chalk.				

III.—A Contribution to the Study of the British Carboniferous Tubicolar Annelida.

By R. Etheridge, Jun., F.G.S., F.R.P.S.Edin.

(PLATE VII.)

(*Continued from p.* 222.)

THE following appear to be well-marked varieties of *Microconchus pusillus.*

1*a.*—*Spirorbis* (*Micro.*) *pusillus,* Martin, var. *simplex,* var. nov. (Plate VII. Fig. 8.)

Var. char.—The coil of the tube is open, lax, and imperfect, representing only a portion of the more developed coil; surface striæ very fine.

Obs.—This variety bears a very close resemblance to a small *Spirula.* In all probability it represents the youngest stage of *Sp. pusillus,* and it is just possible that it may be identical with Goldenberg's *Sp. hamatus* (*Gyromices hamatus*),[1] of the Saarbruck Coal-field, in which case, of course, his name would be adopted in preference to that now proposed.

Loc. and Horizon.—Straiton Oil Shale Works, near Burdiehouse, in shale connected with the Burdiehouse Limestone. Cement-stone group, of the Calciferous Sandstone Series (*Mr. J. Bennie*).

1*b.*—*Sp.* (*Micro.*) *pusillus,* Martin, var. *Hibberti,* Etheridge, jun.

Nautilus, Hibbert, Trans. R. Soc. Edin. 1836, xiii. p. 151.
„ Rhind, Excursions around Edinb. 1836, p. 35, f. 14*c.*
Sp. carbonarius, Murch., var. *Hibberti,* Eth. jun., Quart. Journ. Geol. Soc. 1878, xxxiv. pt. 1, p. 3 (note), t. 1, f. 2.

Var. char.—Size exceeding that of normal examples of the species itself, the last turn of the tube increasing more rapidly; aperture with a sigmoidal or nautiliform margin reflected somewhat back over the umbilicus, which is deep. By following the direction of the surface-striæ, the sigmoidal margin can be traced.

Obs.—Dr. Hibbert figured in his paper, "On the Freshwater Limestone of Burdiehouse, etc.," published in 1836, a little shell-like body which he compared to a *Nautilus,* but noticed its want of septa. I have observed a similar in several shales at about the horizon of the Burdiehouse beds associated with *Microconchus pusillus,* but always to be distinguished from it by its larger size and regularly sigmoidal aperture. They may be only large crushed examples of the typical form of the species, although I hardly think this; at any rate they are far too common to be passed over in silence. I therefore proposed for them some time ago the varietal name *Hibberti.*

Loc. and Horizon.—Similar to the last (*Mr. J. Bennie*).

Section, *Spirorbis,* Lamarck.

2.—*Spirorbis ambiguus,* Fleming. (Plate VII. Figs. 9–11.)

S. ambiguus, Fleming, Edinb. Phil. Journ. 1825, xii. p. 246, t. 9, f. 3.
„ Bronn, Index Pal. Nomen. 1848, p. 1185.
„ Etheridge, jun., Geol. Mag. 1877, IV. p. 318.

Sp. char.—Tube globose, dextral, whorls one, to one and a half,

[1] Fauna Saræpontana Foss. 1877, heft 2, p. 7, t. 2, f. 34, *a* and *b.*

but concealed by the last volution, attached by one side, and expanding towards the aperture; umbilicus open and unconcealed: back broad; surface plain or very finely wrinkled across; aperture round, and somewhat produced; gregarious in habit.

Obs.—*S. ambiguus* was described by the Rev. Dr. Fleming in his paper on the British Testaceous Annelides, and appears to have been almost entirely overlooked by subsequent writers. It was placed by Dr. Fleming in the second division of his arrangement of the species in the genus *Spirorbis*, or in those with the "shell destitute of longitudinal ridges." This species is decidedly gregarious, living in small clusters together, and is almost always found on the shells of Mollusca. The surface is plain, with the exception of a few accretion striæ, which are usually more marked round the margin of the umbilicus.

In the marine limestones and associated strata of the Carboniferous period, *S. ambiguus* appears to take the place of the burrowing form *S.* (*Microconchus*) *pusillus*, so essentially characteristic of the more brackish-water deposits of the same epoch, especially the Calciferous Sandstone Series of Scotland; but I have never seen an individual of *S. ambiguus* from the limestone series with this burrowing tendency.

I can see little or no difference between the specimens of *S. ambiguus* I have examined and the figures of M'Coy's *S. globosus*,[1] and I strongly suspect that when a comparison of specimens can be made, the one will be found to be indistinguishable from the other. They are both dextral and globose; both have a broad back for the size of the tube; both are to all intents and purposes smooth, and the volutions are concealed by the last whorl, if more than one, or one and a half exists. The only apparent difference between the two is in the umbilicus, which, in *S. ambiguus*, certainly cannot be said to be small.

Mr. R. Howse[2] quotes *S. globosus* from the Permian of Humbleton Hill, so, if identical with the present species, the upward range of the latter will be much increased. I am indebted to my friend Prof. F. von Roemer, of Breslau, for specimens of *Spirorbis omphalodes*, Goldf., from the Eifel, and I really can hardly distinguish between this and well-grown examples of *S. ambiguus*, so much are they alike; the latter is perhaps a little more striated. If identical, I can hardly indicate which name has priority. Fleming's name was given in 1828, that of Goldfuss between 1826 and 1833.

In some specimens of *S. ambiguus*, whether from accident or not, it is difficult to say, the sides of the shell become compressed and concave near the periphery, giving to the latter the appearance of a bordering keel. This is usually seen in attached specimens and is probably accidental.

The unnamed *Spirorbis*, figured by Mr. J. de C. Sowerby[3] from

[1] Synop. Carb. Foss. Ireland, p. 169, t. 4, f. 10.
[2] "Catalogue," etc., Trans. Tyneside Nat. Field Club, 1848, i. p. 258.
[3] Trans. Geol. Soc. 1840, 2nd ser. v. t. 40, f. 1*c*.

the Penneystone Ironstone of the Coalbrookdale Coal-field, has all the appearance of *S. ambiguus*.

Loc. and Horizon.—Cults Lime Works, near Pitlessie, Fife, on the valves of *Myalina crassa*, Fleming; Roscobie Quarry, near Dunfermline, Fife; Skateraw Quarry, near Dunbar; Gilmerton Old Quarry, near Edinburgh; Galabraes and North Mine Quarries, near Bathgate, all horizons in the Lower Carboniferous Limestone group. Shore, east of Ravenscraig Castle, Pathhead, Fife, in shale of the Upper Carboniferous Limestone group (*Mr. J. Bennie*).

3. *Spirorbis helicteres*, Salter. (Plate VII. Figs. 12–15.)

S. helicteres (Salter), Rev. T. Brown, Trans. R. Soc. Edinb. 1861, xxii. p. 401, f. 3.
" Salter, Mem. Geol. Survey Scot., No. 32, 1861, p. 145 (*without description*).
" Young, Proc. Nat. Hist. Soc. Glasgow, 1878, iii. pt. 3, p. 329.
" Bigsby, Thes. Dev.-Carbonif. 1878, p. 243 (*ibid*).
" Etheridge, jun., Quart. Journ. Geol. Soc. 1878, xxxiv. pt. 1, pp. 4 and 22 (*ibid*).

Sp. char.—Tube forming on open helix, whorls laterally compressed; as a rule the first two only are compact and discoid, the remainder being elongately extended, twisted, and often a quarter of an inch in length; aperture oval, with a plain thin margin; surface non-striate, but marked with irregularly-wrinkled rugæ; habit unattached, gregarious.

Obs.—The original description of this species was furnished by the late Mr. J. W. Salter for the Rev. T. Brown's paper, "On the Mountain Limestone and L. Carboniferous Rocks of the Fifeshire Coast, etc.," and was drawn up from specimens discovered by Mr. Brown.

The extended portion of the tube sometimes turns or twists upon itself, in an open elongated and loose helix, at others it curves about in an irregular manner. *S. helicteres* appears to be quite unattached to any foreign body, this character being alluded to by Mr. Salter in the following words: "It occurs in distinct beds, hundreds grouped together, yet without ostensible attachment to any other object than its own species." Mr. Salter considered *Sp. helicteres* to be allied to *Serpula Archimedis*, de Kon.;[1] the latter is, however, less compressed, more closely coiled, and has close-set striæ and large transverse plaits. Both *Spirorbis caperatus*, M'Coy, and *Serpula carbonaria*, Binney, terminate in free tubes, more or less coiled; but the former, at any rate, is easily to be distinguished from the present species, although it would be well to make a comparison between Mr. Binney's form and the latter; I think they will be found to approach one another very closely, although the free tube of *Serpula carbonaria*, Binney, does not appear to be at all tortuous, or bent on itself.

Unless seen in mass on the weathered surfaces of hand specimens of limestone, when its peculiar characters become at once apparent, it is, at times, difficult to distinguish *Sp. helicteres* from *S. pusillus*. The coiled portions of both are much alike at first sight—both

[1] Descrip. des Anim. Foss. p. 57, t. G. f. 6.

dextral, convex on one side, flattened, or irregularly piled on the other, and almost similarly marked. It may, however, be said generally, that the coiled portion of *S. pusillus* is wound much more closely than *S. helicteres*, the volutions less in the same plane with one another, and the termination of the last whorl, where it quits the coiled portion of the tube, directed more to one side than in Salter's species. In mass, the peculiarities of *S. helicteres* become very marked, especially the compressed tortuous tube with from four to six turns, or open volutions. I have examined authenticated examples of *Serpula subannulata*, Portlock,[1] from Co. Derry, in the Museum of Practical Geology, and I believe this species to be only a large condition of *Spirorbis* or *Serpula helicteres*, Salter, in which case Portlock's name will have to be adopted.

The internal structure of *Sp. helicteres* has been studied by Mr. J. Young, who states that the tubes are traversed by thin, concave, and imperforate, transverse septa, placed at irregular distances, and so coinciding with the structure of certain recent *Serpulæ* in the Hunterian Museum.[2] In fragments of the free tube from Liddesdale, sent to me by Mr. Bennie, these divisions are sometimes to be seen, and the tube appears to possess a peculiar facility for breaking across into small pieces at these diaphragms.

Loc. and Horizon.—Shore, near Fifeness, to the N.W. of the Balcomie Sands, Fife (*Rev. T. Brown*); Clubbiedean Reservoir, N. end of the Pentland Hills (*J. W. Salter*, Geol. Survey Scot.);[3] Nether Tarisch, on the Ayr Water, E. of Sorn (*A. Macconochie*, Geol. Survey Scot.); Ayrshire coast, between the Heads of Ayr and the "Deil's Dyke" (*J. Young*)[4]; these localities are all in the Cement Stone Group of the L. Carboniferous series of Scotland; it is, however, stated by Mr. Young that *S. helicteres* occurs in a thin mussel-band ironstone of the Coal-measures at Newton Cambuslang.[5]

4.—*Spirorbis caperatus*, M'Coy. (Plate VII. Figs. 16–18.)

Spirorbis caperatus, M'Coy, Synop. Carb. Lime. Foss. Ireland, 1844, p. 169, t. 23, f. 26.
,, ,, Morris, Cat. Brit. Foss. 1854, 2nd ed. p. 1 (*without description*).
,, ,, Etheridge, jun., Mem. Geol. Survey Scot. Expl. 23, 1873, p. 98.
,, ,, Armstrong and Young, W. Scot. Foss. 1876, p. 43 (*without description*).
Serpula et Spirorbis caperatus, Bigsby, Thes. Dev.-Carbonif. 1878, p. 243 (*ibid.*).

Sp. char.—Tube discoid forming a closed helix of two whorls, and then becoming extended into a produced and somewhat curved free portion; section round; surface occupied by equidistant, sharp and prominent, transverse ridges. Usually attached to the surface of shells, etc.

Obs.—This species was described by Prof. M'Coy from a single specimen, so that we must not expect his figure to present all the characters of the form as presented by a number of specimens. I

[1] Geol. Report, Londonderry, p. 363.
[2] Proc. Nat. Hist. Soc. Glasgow, iii. p. 329.
[3] Mem. Geol. Survey Scot. No. 32, p. 145.
[4] *loc. cit.* p. 328. [5] *loc. cit.* i. p. 102.

believe I am correct in considering Fig. 16 as the form which has been universally referred in Scotland to this species.

Sp. caperatus frequently occurs attached to the surface of shells, but specimens have come under my observation without presenting any visible evidence of attachment. As originally figured, the tube terminated immediately following the second turn of the helix, but some time ago I pointed out that in many cases the shell was extended into a prolonged more or less curved free portion. I believe small granules can be detected on some specimens, studding the sharp transverse ridges; but on this point I cannot speak with certainty, as the specimens may have been deceptive.

A close ally of this species is the *S. Arkonensis*, Nicholson,[1] which has similar concentric ridges, and the mouth turned upwards. It is, however, both dextral and sinistral.

Spirorbis laxus, Hall,[2] is annulated and ends in a free tube like *S. caperatus*, but the annulations are more distinct, direct, and farther apart, judging from figures.

Loc. and Horizon.—Occurs at many localities throughout the Scotch Carboniferous Limestone Series. Specimens before me are from Galabraes Quarry, near Bathgate; Roscobie Quarry, near Dunfermline; Catcraig and Skateraw Quarries, near Dunbar; the quarry at Carlops, Peebles-shire; all from shale connected with the Lower Limestones of the Carboniferous Limestone Series[3] (*Mr. J. Bennie*).

5. *Spirorbis spinosa*, de Koninck. (Plate VII. Figs. 19–21.)

Serpula spinosa, de Kon., Descrip. des Anim. Foss. p. 58, t. G. f. 8, a—c.
„ Bronn, Index Pal. Nomen. 1849, p. 1139 (*without description*).
Spirorbis „ Etheridge, Jun., Mem. Geol. Survey Scot. Expl. 23, p. 86 (*ibid*).
„ „ Armstrong and Young, Cat. W. Scot. Fos. 1876, p. 43 (*ibid*).
Serpula, et *Spirorbis spinosa*, Bigsby, Thes. Dev.-Carb. 1878, p. 243 (*ibid*).

Sp. char.—Tube globose, forming a closed globular helix of from three to four whorls; back broad, its lateral margins more or less crenulate; umbilicus deep; section circular; surface covered with small, sharp prickles, or abortive spines, arranged in quincunx, and here and there a few transverse wrinkles.

Obs.—The rarity of *S. spinosa* in the Carboniferous rocks of Belgium is only equalled by its uncommon occurrence in those of Scotland.

From *S. caperatus*, M'Coy, to which it at first bears some resemblance, the present species may be distinguished by the absence of the regular transverse ridges or rings of the former, a much broader back to the helix, and, so far as I know at present, the absence of the free terminal tube. If I am correct in stating that *S. caperatus* has small spines or prickles, a good point of similarity will be established, but not one sufficient for their union, because in *S. spinosa* the spines are scattered broadcast over the surface, whilst in *S. caperatus*, if they exist, they are confined to the crests of the annulations, and at the best only form a roughening of the latter.

[1] Pal. Ontario, 1874, i. p. 121, f. 54, *b* and *c*.

[2] Pal. N. York, iii. p. 349; Atlas, t. 54, f. 18, *a*—*e*.

[3] For localities in the West of Scotland, see Armstrong and Young's "Catalogue," and Mem. Geol. Survey Scotland, No. 23.

S. spinuliferus, Nicholson,[1] is allied to *S. spinosa* in the presence of strong spiniform projections.

Loc and Horizon.—Skateraw and Catcraig Quarries, near Dunbar; Burlage Quarry, near Dunbar; in shale of the Lower Carboniferous Limestone Group; Gair Quarry, near Carluke, etc., in shale of the Upper Carboniferous Limestone Group (*Mr. J. Bennie*).

6.—*Spirorbis?* (*Serpula*) *Archimedis*, de Koninck?

Serpula Archimedis, de Koninck, Descrip. des Anim. Foss. p. t. G, f. 6.
,, ,, Bronn, Index Pal. Nomen. 1848, p. (*without description*).
,, ,, Bigsby, Thes. Dev.-Carb. 1878, p. 243 (*ibid*).

Obs.—Mr. Bennie has found a single specimen which appears to have relation with the above species. Unfortunately it is only an internal cast, but the turriculated form of the coil, and certain indistinct traces of transverse ridges, such as are described by Prof. de Koninck in *S. Archimedis*, render it likely that we may have to catalogue this as a British form.

Loc.—Law Quarry, near Dalry, Ayrshire—Carboniferous Limestone Series (*Mr. J. Bennie*).

7.—*Spirorbis Eichwaldi*, sp. nov. (Plate VII. Figs. 22–24.)

Sp. carbonarius, Murchison, *var.* R. Etheridge, jun., Geol. Mag. 1877, IV. p. 319.

Sp. char.—Tube planorbiform, dextral, of from two and a half to three volutions, usually all more or less in the same plane; the volutions convex on one side, the upper, but flattened on the lower, as if by attachment. Surface usually quite smooth, but sometimes with a few transverse ridges; the periphery of the tube sharp, produced into a series of short, minute, regular, spiniform processes. Aperture oval; umbilicus shallow and open.

Obs.—In a few "Palæontological Notes" communicated to the Geological Magazine I pointed out the occurrence of this peculiar and pretty form of *Spirorbis* in the Lower Carboniferous beds of the Edinburgh neighbourhood, which so directly calls to mind the Russian Silurian species, *S. Siluricus*, Eichwald.[2] Formerly I considered it better to regard *S. Eichwaldi* only as a variety of the common Lower Carboniferous form, but on reconsidering the matter, and after the examination of a large number of individuals of the latter from different localities, and free from matrix, kindly prepared for me by Mr. Bennie, it appears to me necessary to keep *S. Eichwaldi* distinct from *S. pusillus*, Martin (= *S. carbonarius*, Murch.). Of the many hundred examples of the latter I have examined not one has presented the tubercular periphery of *S. Eichwaldi*, and, *per contra*, all the individuals of the latter which have come under my notice have possessed this character. From *S. Siluricus*, Eichwald, our new form differs in a much less degree, but it may be stated generally that the shell is much larger in the former, and the spinous processes are smaller and less developed; the aperture is semilunar instead of oval, and the umbilicus deep instead of open and shallow.

[1] Pal. Ontario, pt. 2, pp. 83 and 84, f. 44*c*.
[2] Lethæa Rossica, i. p. 668, t. 34, f. 1, *a–c*, 2 *a* and *b*.

In the Permian *Spirorbis planorbites*, Munster, the periphery appears to be somewhat crenulated by minute projections as shown in one of the figures of this species given by Geinitz,[1] but this crenulation bears no comparison with that of *S. Eichwaldi.*

Loc. and Horizon.—Quarry on bank of Linnhouse Water, opposite the Oakbank Oil Works, near Mid Calder, in a limestone of the Cement Stone Group (Calciferous Sandstone Series), associated with *Sp. pusillus,* and bivalves (*Mr. J. Bennie*).

8.—*Spirorbis Armstrongi,* sp. nov. (Plate VII. Fig. 25.)

Sp. char.—Tube planorbiform, dextral, the last turn large, and more or less covering the others. Surface spirally lined with microscopic striæ, and crossed transversely at regular intervals by a series of sharp projecting ridges, crests, or frills.

Obs.—This well-marked species has presented itself only in fragments, with the exception of one specimen, but its appearance is so well marked that I think it deserves to be distinguished by a name. The strong frills or crests which cross the surface of the shell, accompanied by the spiral fine striæ, render this a conspicuous species.

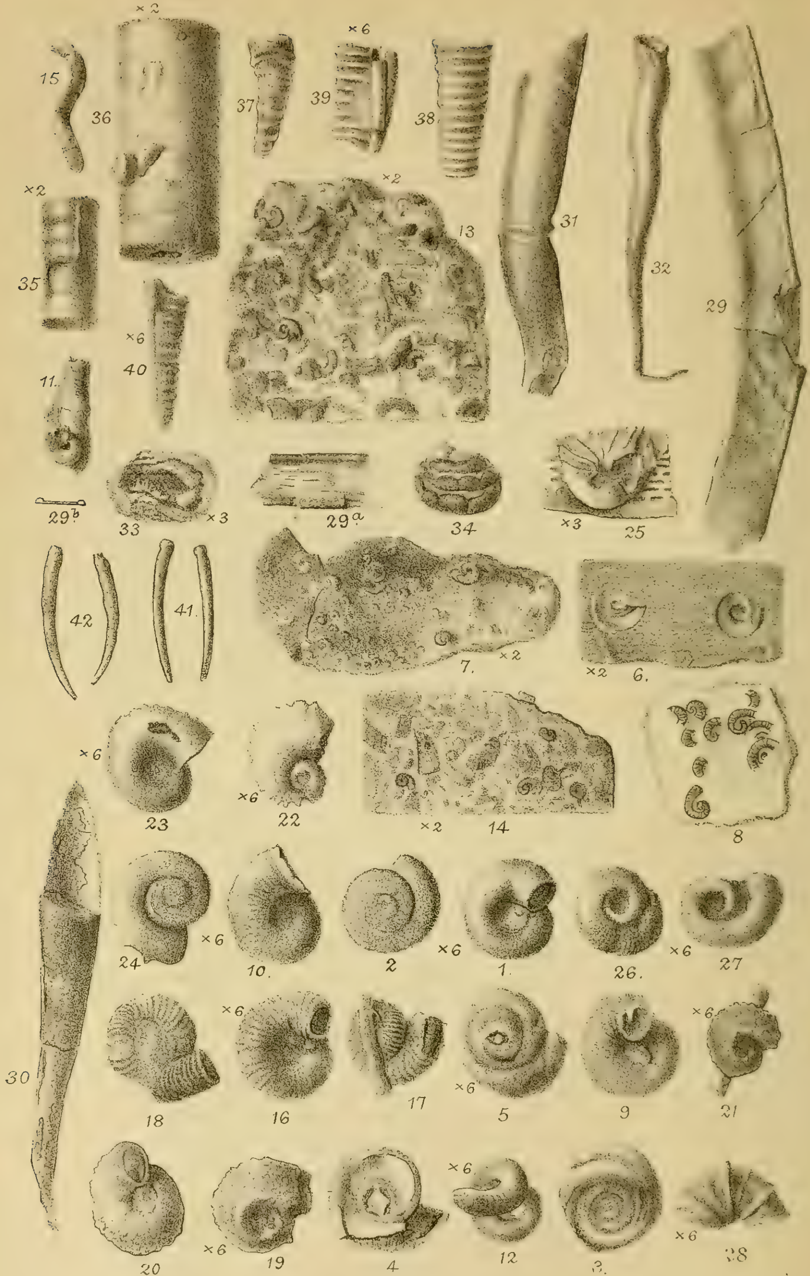
The nearest ally of *S. Armstrongi,* so far as I have been able to ascertain, is *Spirorbis* (*Serpula*) *epithonia,* Goldfuss,[2] which has similar transverse frills, but of a less degree, and no spiral striæ, as in the present species. Next to this is *Spirorbis laxus*, Hall,[3] from the Lower Helderberg Group, but in this instance the ridges which cross the surface of the shell are mere annulations, and do not extend beyond the periphery, whereas in our *S. Armstrongi* the crests are sharp and erect, and in fact at times have an imbricating appearance, as if representing successive growths of the tube which overlap one another. There is in this character, but in no other, a connexion with *Serpula scalaris,* M'Coy,[4] in which the same imbricating or overlapping of the successive growths of the tube is seen.

Spirorbis angulatus, Hall,[5] is described as having the surface lamellose striate, the lamellæ being crowded into ridges; without a figure it is difficult to say how far this would correspond with the present species; it is however probable that it somewhat resembles it so far, although the "upper angular side, sometimes nodose," would at once separate them, as there is no trace of nodes in *S. Armstrongi.*

I have much pleasure in associating with this species the name of Mr. J. Armstrong, whose researches in Carboniferous Palæontology are too well known to require comment from me.

Loc. and Horizon.—Carlops Quarry, Peebles-shire, in shale over the Carlops Limestone, L. Carboniferous Limestone Group (*Mr. J. Bennie*).

[1] Dyas, t. 10, f. 10.
[2] Petrefacta Germaniæ, t. 67 f. 1.
[3] Pal. N. York, iii. t. 54, f. 18 *a–e.*
[4] Synop. Carb. Lime. Foss. Ireland, t. 23, f. 29.
[5] Fifteenth Ann. Report State Cab. Nat. Hist. N. York, 1862, p. 112.



G.M.Woodward del. et lith.

West Newman & Co. imp.

Carboniferous Tubicolar Annelida.

EXPLANATION OF PLATE VII.

FIG. 1. *Spirorbis* (*Microconchus*) *pusillus*, Martin. An example free of matrix, showing the exposed side of the tube, with the aperture bent to one side. × 6. Calciferous Sandstone Series, Linnhouse Water, near Mid Calder.

,, 2. The same. Another specimen illustrating the flattened, or wholly attached side. × 6. Same horizon and locality.

,, 3. The same. A third example, showing the attached side, bearing a groove, the vacuity left by the body of attachment. × 6. Same horizon and loc.

,, 4. The same. A spec. exhibiting a hollow section of the tube. × 6. As before.

,, 5. The same. An example showing the piled condition of the tube, with a minute groove of attachment at the apex of the pile. × 6. As before.

,, 6. The same. Four specimens burrowing in the substance of a leaf of *Cordaites*. × 2. In shale, Ireland.

,, 7. A cluster of the same species on the interior of portion of a Myaliniform shell. × 2. L. Carboniferous, River Tweed, below Coldstream Bridge.

,, 8. Var. *simplex*, R. Eth. jun. The simplest condition of this species. × 2. Wardie shales, Straiton Oil Works, near Burdiehouse.

,, 9. *Spirorbis ambiguus*, Fleming. A characteristic example, from which the striæ of growth have been omitted. × 6. L. Carboniferous limestone group, Roscobie, near Dunfermline.

,, 10. Another specimen from the same locality.

,, 11. A large decorticated individual adhering to a fragment of coral (?). × 2. Law Quarry, near Dalry.

,, 12. *Spirorbis helicteres*, Salter? A portion of the decorticated free tube? × 6. Law Quarry, near Dalry.

,, 13. *Spirorbis helicteres*, Salter. Scattered over the weathered surface of a piece of "Spirorbis-limestone." × 2. Carboniferous limestone? Mitchell Dean, Gloucestershire.

,, 14. A microscopic section of same, showing the hollow condition of the tubes.

,, 15. Another specimen of the free portion of the tube of this species? × 4. Law Quarry, near Dalry.

,, 16. *Spirorbis caperatus*, M'Coy. A typical example. × 6. L. Carboniferous limestone group, Burlage Quarry, near Dunbar.

,, 17. Another example of the same, showing its attachment to a small spine. × 6. L. Carboniferous limestone group, Skateraw Quarry, near Dunbar.

,, 18. The same. With a portion of the short free tube. × 6. Inverteil Quarry, near Kirkcaldy.

,, 19. *Spirorbis spinosa*, de Koninck. A small specimen in which the spines are but faintly represented. × 6. L. Carboniferous limestone group, Skateraw Quarry.

,, 20. The same. Another example showing the mouth. × 6. Same horizon and locality.

,, 21. The same. Attached to a small Crinoidal stem. × 6. As before.

,, 22. *Spirorbis Eichwaldi*, R. Eth. Jun. A typical specimen with the large expanded terminal whorl and spinous periphery. × 6. Calciferous Sandstone Series, Oakbank Oil Works, near Mid Calder.

,, 23. A somewhat less crushed form of the same. × 6. From the same locality.

,, 24. Another example, showing the flattened attached side. × 6. Same locality, etc.

,, 25. *Spirorbis Armstrongi*, R. Eth. Jun. A rather crushed specimen attached to a fragment of *Sulcoretepora*, with the strong lamellar ridges shown. × 3. L. Carboniferous limestone group, Carlops.

,, 26 and 27. *Spirorbis Dawsoni*, R. Eth. Jun. Two examples of this minute species. × 6. L. Carboniferous limestone group. Fig. 26, from Seafield Tower, near Kirkcaldy; Fig. 27 from the "Vaults," near Dunbar.

,, 28. *Spirorbis*, sp. ind. A fragment with very strong accretion ridges. × 6. L. Carboniferous limestone group, Burlage Quarry, near Dunbar.

,, 29. *Serpulites carbonarius*, M'Coy. A fragment of a very large specimen, with the thickened marginal ridges. The surface should have been slightly striated transversely. Fig. 29A. Another fragment with a longitudinally wrinkled surface. Fig. 29B. Cross section of the same. Nat. size. Carboniferous limestone? Lesmahagow.

FIG. 30. *Serpula indistincta*, Fleming, sp. The original specimen figured by Sowerby. Nat. size. W. Lothian.
,, 31. The same. (*S. subcincta*, Portlock.) Nat. size. Armagh limestone, Ireland.
,, 32. Another example of the same.
,, 33. *Serpula Torbanensis*, R. Eth. Jun. One of the oval clusters of tubes. × 3.
,, 34. *Serpula vermetiformis*, R. Eth. Jun. A specimen showing the peculiar constricted tube of this species. Nat. size. Carboniferous limestone.
,, 35. *Vermilia*, sp. ind. On a portion of a small Encrinite stem. × 2. L. Carboniferous limestone group, Skateraw Quarry, near Dunbar.
,, 36. Another stem bearing two small specimens of the same. × 2. Same locality, etc.
,, 37. *Ortonia Carbonaria*, J. Young. An example in which the transverse ridges and vertical striæ are preserved. × 6. Ravenscraig Castle, near Kirkcaldy, Upper Carboniferous limestone group.
,, 38. A large specimen of the same. × 6. Skateraw, near Dunbar, L. Carboniferous limestone group.
,, 39. A third individual, showing the small spine to which it is attached, and the groove formed by it. × 6. Whitehouse, near Linlithgow, Upper Carboniferous limestone group.
,, 40. Another example, with the groove from which the spine has been removed. × 6. Galabraes Quarry, near Bathgate, L. Carboniferous limestone group.
,, 41. *Ditrupa Ryckholti*, R. Eth. Jun. Two minute examples, many times magnified. Carboniferous limestone, Woodend Quarry, near Fordel, Fife.
,, 42. *Ditrupa*, sp. ind. Recent specimens from Madeira, for comparison with Fig. 41. Nat. size.

The subjects of Figs. 30 and 42 are in the British Museum; Figs. 6, 13, 14, 29, 31, and 32 are in the Mus. Practical Geology; Fig. 34 is in the Cabinet of the Rev. Mr. De-la-Haye; and the remainder are in the Collection of the Geol. Survey of Scotland.

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

IV.—ON THE PRE-CAMBRIAN ROCKS OF WEST AND CENTRAL ROSS-SHIRE.

By HENRY HICKS, M.D., F.G.S.

WITH PETROLOGICAL NOTES.

By T. DAVIES, F.G.S., of the British Museum.

(*Concluded from p.* 226.)

PART IV.

Ben Fin and Mulart.

IN these mountains to the north of the road leading from Glen Docherty to Auchnasheen, the gneiss rocks and mica schists of which they are mainly composed dip at a high angle, and have a strike averaging somewhere about N.W. to S.E.—in some places being nearly due N. and S., in others only a little N. of W. This strike, which is the normal one for the Pre-Cambrian rocks, and very unusual in the newer deposits, occurring here throughout so great a thickness of strata and over a wide area, when we take into consideration the fact also that the rocks themselves present the strongest resemblance possible to many of those found amongst the Pre-Cambrian rocks in the Western areas, furnishes very strong proof that we have here a re-appearance of the old Pre-Cambrian floor.

The range, of which these mountains form a part only, extends along central Ross-shire in a line nearly due E. and W. for a distance of about ten miles. It includes Ben Eigen, and a portion to the east of that mountain. These I was not able to visit, but from the descriptions that have already been given of them, I have no doubt whatever that the interpretations supplied by Ben Fin and Mulart are equally applicable to those portions of the range.

In my former paper I described the rocks composing these mountains as "a highly crystalline series, chiefly gneiss with garnets, mica schists also with an abundance of garnets, and some hornblende schists"; and that "the crystallization is in no way local, but affects the whole series equally; and it is that form so peculiarly characteristic of the older or Pre-Cambrian rocks wherever they are exposed in this country."

I devoted a considerable time to the examination of these mountains, and collected specimens at all horizons as far as this was possible. It is perfectly clear that the vertical thickness of the rocks exposed is very great, but there are distinct evidences also of their being frequently repeated in minor folds. Amongst the specimens collected may be specially mentioned the following varieties:—

1. A rather massive gneiss, consisting of thick bands of coarse-grained white and pink felspar, with quartz, and laminæ of black and white mica with garnets and sphene.

2. A gneiss in which the orthoclase felspar is frequently developed in well-defined crystalline groups, with black and white mica and garnets in large distinct crystals. An *augen-gneiss.*

3. A coarse-grained granitoid gneiss, with garnets and sphene.

4. A fine-grained ditto ditto.

5. A coarse granite, with large flakes of mica (probably a vein).

6. A dull-coloured mica schist, with an abundance of decomposing garnets, giving to the whole a rusty appearance.

7. Bright silvery mica schist, with garnets.

8. A highly micaceous gneiss, consisting of bands of white and black mica, with a moderate amount of quartz and felspar, and some garnets and sphene.

9. A medium-grained hornblende gneiss, with much sphene.[1]

10. A massive hornblende rock, coarse-grained, with much sphene.

Several of the above are more fully described by Mr. Davies in Notes 23–28.

[Note 23.—This rock appears to be a fine-grained foliated gneiss, in which the orthoclase occasionally occurs as large crystals or lenticular groups of crystals, forming the variety called *augen-gneiss.* A thin section shows that quartz is the predominant mineral. Much of it is very intimately crystalline, and in lengthened-out grains according with the direction of the foliation. The grains are only individualized when seen between crossed Nicols. The quartz is very clear, though in some bands there are numerous grains which

[1] Professor Bonney in his paper (Quart. Journ. Geol. Soc. vol. xxxvi. p. 105) says that he "failed to find any hornblendic rock other than intrusive" in Ben Fin. That Nos. 9 and 10 are not intrusive is in my opinion (as also in Mr. Davies's) almost beyond doubt, and I am surprised that Prof. Bonney did not meet with them, especially as he appears to have come across, at an horizon near where these are found, what he calls a "garnetiferous diorite." That, however, he should not have touched all the varieties in his hurried examination of a few hours is not at all surprising, considering that I spent two whole days on these mountains, and had even then to miss many points.

inclose the microscopic "dust." The felspar, which is crystalline with the quartz, is principally a plagioclase. Black dichroic mica with a very little of the colourless variety is in frequent but thin bands. Garnet, sphene, and magnetite are also diffused, but are not abundant.—T.D.]

[NOTE 24.—More compact than No. 15, and less distinctly foliated. The quartz here too is preponderant, and crystalline, the individual grains being crystallized around and into each other. As a result, some of them present an exceedingly irregular form, and partly surround and inclose other crystalline grains of the same mineral. Felspar is sparse, the plagioclase more so, but are intimately crystalline with the quartz. The micas, as in No. 15, are in thin laminæ or aggregations of laminæ, which lie in excessively thin bands. They are not, however, exclusively confined to these, but thin plates are scattered throughout, though all lie approximately parallel to the bands. Garnet and sphene are here in minute crystals.—T.D.]

[NOTE 25.—A medium-grained rock, which, on microscopic examination, appears to consist of quartzo-felspathic bands with thinner bands of mica. Contains also garnets. Under the microscope, thin sections show a mass of intimately crystalline quartz, with some orthoclase felspar so fresh and colourless as to resemble adularia. The nearly colourless monochromatic mica is here the predominant one, and is in larger groups and laminæ than in any of the other rocks examined. Minute doubly refracting crystalline grains, of a pale straw-yellow colour, are also present. These I regard as sphene.—T.D.]

[NOTE 26.—A fine-grained, grey rock, with mica evenly distributed. In transverse section, the foliation is not striking. The quartz here is very intimately crystalline, grouped in wavy bands, rudely lentiform, or lengthened in the direction of the banding. Felspar is almost absent, but for a few crystals or crystalline grains of a plagioclase. The mica is principally biotite, though a few large lenticular groups of muscovite are present. It does not form continuous bands, but is intermittent in its foliation. Sphene is in very minute crystals, with garnet.—T. D.]

[NOTE 27.—This is a very micaceous rock, with small lentiform quartzo-felspathic nests, resembling an *augen-gneiss*. It contains many garnets. A thin section shows the quartz and felspar (plagioclase) to be intimately crystalline, both very clear. The predominant mica, biotite, is in well-defined bands of very distinct crystal groups, and is sometimes interlaminated with and also incloses the muscovite.—T. D.]

[NOTE 28.—A medium-grained crystalline mass of hornblende, with a brown mica, and much crystalline yellow sphene. Foliation is not very distinct, and is chiefly indicated by the lie of the mica. The microscope disclosed a mass of distinct crystals of a green hornblende with clear quartz, which, besides being interstitial, is also inclosed in the hornblende, a dark brown dichroic mica, and sphene crystals throughout. Felspar is not discernible.—T. D.]

In walking over these mountains in all directions, I did not find a single spot where the rocks were not completely crystalline, and the vertical thickness traversed over must have been very great. There was no evidence of a selective metamorphism, but all were equally affected. The mica schists, the true gneisses, and the hornblende rocks, all equally proved that we had here no partial change due to some local cause, but a universal state of crystallization, such as could only have been induced by a wide-spreading cause.

Looking at the physical as well as the petrological evidence furnished by these mountains, I have no hesitation whatever in claiming for the rocks composing them a Pre-Cambrian age, and I believe, moreover, that they can be correlated in almost every particular with the so-called fundamental rocks along the west coast, especially with those exposed about Gaerloch. The petrological notes by Mr. Davies will enable all to realize the present condition of the chief varieties in each area, and if a comparison is made, it will be at once apparent that whatever their primary condition may have been, the rocks in these central mountains have undergone a state of metamorphosis equal in every respect in its intensity to that in the rocks along the west coast. The presence of such distinct minerals as garnet, sphene, etc., in nearly all these crystalline rocks, and their absence, except occasionally in a fragmentary condition, in those which have not undergone this change, is highly important evidence, being indeed to the petrologist, what fossils are to the palæontologist. The state of all the minerals, rather than the preponderance of any, must perhaps be taken into consideration chiefly in these inquiries; but in addition there can be no doubt that the actual development of minerals which could not have been present in the sediments, such as sphene, garnet, etc., in tolerably regulated proportions, is evidence clearly of the utmost value in any attempt at correlating the metamorphic rocks of different areas.

[Petrological Remarks.—In the foregoing paper it will be seen that no rock has been regarded as a gneiss which did not contain the minerals quartz and one or more felspars, in an intimately crystalline condition. It may be observed also that the minerals sphene and garnet have been found to be almost universally present in rocks of this type from this area, the former being frequently abundant. The term schist has been restricted to those rocks, deficient in quartz but rich in mica, in which the quartz appears to have parted with its detrital character, and the crytalline grains have become so moulded together that even with the aid of polarized light it was found difficult to determine the original boundaries of individual grains.

Comparing the rocks of Gaerloch and Loch Maree (Notes 1—8), with those of Ben Fyn (Notes 21—28), the same intimate crystallization of the quartz and felspar is apparent which is characteristic of the true gneisses, with a similar variability in the proportions of these constituents. They are also characterized by the presence of the minerals sphene and garnet, which also vary in amount. The former is of a pale yellow colour and in distinct crystals, is more abundant in the mica bands; the latter is frequently exceedingly pale in colour, often colourless, and is recognized in thin section by its crystal outline and the absence of double refraction. It is probably a lime-alumina garnet, and is more evenly distributed than the sphene.

Amongst the rocks from Ben Fyn I found none which could be grouped with those described in Notes 15—20, of the upper series, the nearest approach to the most highly altered of which being a specimen from Gaerloch (Note 1), and some fragments from the conglomerate from that neighbourhood; though in these cases the crystallization is still more distinct than in any of those of the newer series, whilst the presence of both sphene and garnet serves to show its true relations.

The foliation of the gneisses, although rendered more distinct by the presence of the mica bands, is by no means wholly dependent upon the parallel arrangement of the laminæ of this constituent, this character being often contributed to in a marked degree by the form of the quartz in the quartzo-felspathic bands (v. Notes 2 and 7). On the contrary, the schistosity of the quartzites of the upper series (often miscalled gneiss) is entirely due to this parallelism of the mica flakes, the remainder of the rock, even where felspar is present, showing few or no indications of the foliation of the gneiss. Sphene very rarely occurs in the quartzites (however micaceous), both this and the garnet being always fragmentary.

The bands of hornblende rocks in the gneiss from Ben Fyn are closely similar to those of Gaerloch and from other western areas which I have examined, and they contain abundance of sphene. It may be noted *en passant* that many of the rocks hitherto designated hornblende-gneisses contain no trace of hornblende, the black mica having probably been mistaken, in the majority of cases, for this mineral. That it occasionally occurs there can be no doubt; but it does not appear to be in any way a characteristic of the gneisses of this area.

The intergrowth of biotite and muscovite observed in one of the specimens from Ben Fyn—recalling to mind the not-infrequent interlamination of two species of chlorite—was new to me; but I have since found that Zirkel has called attention to such an occurrence in an Archæan gneiss from the Ogden Cañon, Wahsatch Mountains, Utah, U.S.A.[1]—T.D.]

General Conclusions.

The evidence given tends to show conclusively that a floor of Pre-Cambrian rocks can be traced almost continuously along certain lines from the west coast to the central mountains of Ross-shire. That it attains in some cases to heights of over 3000 feet above the present sea-level, whilst at others it descends to that level, and even below it. It has a very uneven surface, but the main depressions are along well-defined lines. The most marked being those which trend in lines from N.E. to S.W. In these depressions newer sediments have accumulated, chiefly rather shallow-water deposits, and such as would be derived by the denudation of the rocks composing the floor. Some, however, there are like the limestones, which must

[1] Microscopical Petrography, F. Zirkel, p. 24.

have been derived chiefly from organic life, in a quiet and somewhat deeper sea. The condition of the rocks composing the floor at the time is clearly indicated in the fragments plentifully found in the newer deposits. These show clearly that when broken off the rocks must have been not only indurated but crystalline, and that since that time little, if any, further change has taken place in them. The faults which occur are mainly in two directions, viz. from N.E. to S.W. and from N.W. to S.E., and the lochs, lakes, and valleys usually follow the lines of these faults. Probably the main anticlinal axis of the old rocks in the neighbourhood under consideration occurs nearly in the line of Loch Maree. The deeper beds being found along both sides of that lake, and the higher at Ben Fin and Mulart on the one side; and about Gaerloch on the other. Numerous minor folds of course are seen, but this seems to be the main one.

The petrological evidence tends further to show that the newer rocks, even when partially altered by contact with intrusive rocks, or otherwise, never properly assume the character of the old rocks, and that the difference between them is easily recognizable under the microscope.

In addition, evidences of an entire discordance in strike in the beds, and of having suffered very unequally from the physical changes which have affected the crust, are also usually most marked.

In attempting to correlate the Pre-Cambrian rocks of these areas with those of Wales and elsewhere, we can at present only say definitely that the physical and mineral evidences tend to associate them with the Dimetian rocks. The thickness here is probably greater than in any area in Wales, and there is therefore a greater variability in their character.

Whether they all belong to one conformable series is also a question of considerable importance. It may be that in the centre of the axis along Loch Maree an older formation is found than at the other points mentioned. We may here have the Lewisian exposed, and a gradual passage between the two formations; whilst on the other hand it is not impossible that even here they may be unconformable, as in other areas, to one another.

In conclusion it is perhaps even now not too much to say that the same general results met with here are not only likely to be obtained by explorations along other lines to the N. and S., but highly probable from much of the evidence already accessible.

V.—Notes on the History and Comparative Anatomy of the Extinct Carnivora.

By P. N. Bose, B.Sc. (Lond.), F.G.S.

(*Continued from p.* 207.)

The dentition of *Gymnura*, an existing Insectivorous Mammal, may with advantage be compared with that of the Eocene Carnivora. The dental formula of *Gymnura* is typical:—

$$i.\ \frac{3-3}{3-3}\ c.\ \frac{1-1}{1-1}\ pm.\ \frac{4-4}{4-4}\ m.\ \frac{3-3}{3-3} = 44.$$

The only other existing Mammals which have 44 teeth are the

Pigs and the Moles. But in Eocene times, this number, as first noticed by Professor Owen, was the rule, instead of being the exception.

(*A.*) *Upper Jaw.*—In *Gymnura* the first two molars (*m.* 1 and *m.* 2) are each composed of four tubercles interconnected by ridges, the ridge connecting the postero-external with the corresponding internal tubercle being oblique and swelling about half-way into a small mammillon, as in the *Pliolophus* of Prof. Owen. The last molar, which is the smallest, has become subtriangular by the reduction of the postero-internal tubercle. This process of reduction has not been carried so far in the last false molar (*pm.* 4), the homologue of the sectorial tooth of the Carnivora. It is the largest premolar; the anterior of the two external cusps is developed at the expense of the posterior one, the former being the most elevated in the entire molar series. It inclines slightly backwards, is mapped off by a small notch from a rudimentary accessory cusp in front, and descends posteriorly into a low horizontally extended portion (the representative of the posterior outer tubercle). Of the two inner tubercles, the posterior is smaller than the anterior. In premolar 3, the former has aborted altogether; this tooth is composed of a large pointed, trihedral, external cusp (similar to the corresponding cusp of *pm.* 4), with a rudimentary anterior accessory cusp in front and the remains of the posterior tubercle behind; there is only one internal tubercle, so that the tooth is three-fanged. There is nothing remarkable in the remaining teeth, except that the canine is two-fanged, conical, and curved inwards. If this tooth became one-fanged, sharper, longer, and more trenchant, as in *Centetes*, we would have the typical canine of the Carnivora. If, as in the Moles, Hedgehogs, etc., the antero-internal tubercle of the third premolar (which has the form of a sectorial) aborted altogether, we would get the corresponding false molar of the Carnivora. The fourth premolar of *Gymnura* is hardly distinguishable from the sectorial of *Procyon*, one of the *Subursidæ*. If the inner and hinder tubercle vanished entirely, as it does in *Talpa*, *Glisorex*, *Ericulus*, *Centetes*, etc., the tooth would assume the form of the normal sectorial of the Carnivora. A similar modification in the first and second molar teeth would give us a series of three-fanged teeth, triangular in section, with two outer lobes and an inner tubercle. Such a succession of "sectorials" is presented by so many Insectivores, that it may be considered to be the normal condition in that order. And it is very strange, indeed, that eminent comparative anatomists have failed to find a parallel for a similar modification of the molar teeth in the Eocene Carnivores, except amongst the *Didelphia*. The hindermost molar is very variable in form and size in the order of the Insectivora; it is small and transverse in *Erinaceus*.

All the Eocene Carnivores, with one or two exceptions, have seven molars on each side of the upper jaw. The incisors are always three in number, as in the typical Carnivora; in the Aplacental flesh-eaters, on the other hand, the number of incisors is invariably more than three. In *Arctocyon*, the sectorial, as may be inferred from its remains, was of moderate dimensions; the three molars, which are all well preserved, are constructed on essentially the same pattern as the corresponding teeth of *Gymnura*. In *Amphicyon* the sectorial is better developed, and the length occupied by the molar series behind the sectorial proportionately lessened; first by diminution in size of the hindermost molar; and, secondly, by the first and second molars losing their primitive quadrangular structure, and becoming longer transversely than antero-posteriorly. In *Cynodon* the sectorial is still more differentiated than in *Amphicyon*, and the space occupied by the true molars correspondingly shortened, the last molar being altogether absent in some species constituting the subgenus *Cynodictis*. The upper-jaw teeth of *Arctoycon*, *Amphicyon*, and *Cynodon*, besides agreeing in number and general form and arrangement, have this important point of resemblance in common, viz. that there is one tooth more or less differentiated as a flesh-cutting tooth, and that the three teeth behind it preserve more or less of their primitive structure, and may be properly called "tuberculous." But in *Proviverra*, *Hyenodon*, and *Pterodon* of the European Eocene, and *Ambloctonus*, *Oxyæna*, and *Stypolophus* of the Lower Eocene of New Mexico, there is a succession of three or four similar teeth having the form of the sectorial. In *Ambloctonus* all the three true molars have this form; in *Proviverra*, as well as *Stypolophus*, the hindermost molar has become transverse; and *Oxyæna* differs from *Stypolophus* (= *Proviverra*) only in having one molar less. The upper-jaw teeth of *Pterodon* and *Hyenodon* are constructed on the same type as those of *Proviverra*, only the last molar is proportionately more reduced in size in *Pterodon*, and is generally absent in *Hyenodon*.[1] The presence of several "sectorials" has been remarked by Prof. Gaudry to be "peculiar to the Marsupials." But, as we have noticed above, it is very common amongst the Insectivores (e.g. *Talpa*, *Centetes*, *Glisorex*, etc.). There is, however, one fatal objection to the institution of a comparison between the molars of the Eocene Carnivores mentioned above and those of Thylacine or Dasyure; and that objection will be noticed, after we have explained the most important points in the dentition of the lower jaw.

(*B.*) *Lower Jaw.*—In *Gymnura*, the incisors are smaller than in the upper jaw, and the canine proportionately larger, stronger, and more recurved, attaining in *Centetes*, as in the upper jaw, the typical form and dimensions of the Carnivora. The premolars are conical and trenchant; the first two are small and simple, the third and fourth considerably larger, and the latter with rudimentary anterior and posterior cusps. The true molars are all quadricuspidate, decreasing in size from the first to the third. The structure of the first molar is most instructive. The anterior pair of cusps is more elevated than the posterior; the cingulum from the external border of the tooth is produced forward and inward, and the cingulum from the internal border is slightly produced so as to meet its fellow from

[1] Prof. Gervais (*op. cit.* p. 232) is of opinion that there is a very small molar behind *m.* 2 in *H. leptorhynchus*.

the outer border in front of the anterior pair of cusps in the interspace between them. The point in which they meet is slightly elevated; if it were better developed (as it is in *Rhynchocyon* and *Centetes*), the tooth would assume the form of a typical lower carnassial. The two posterior tubercles with the space intervening between them and the anterior pair would form the "heel," and the two anterior cusps with the accessory cusp in front the strictly "carnassial" part. It may be observed that the development of this cusp is inversely proportional to that of the antero-internal cusp and to the tubercular part behind (the "heel"); and in the *Felidæ*, in which the anterior accessory cusp is best differentiated, the representative of the primitive antero-internal cusp (present in the *Canidæ*, *Viverridæ*, etc.) as well as the "heel" disappear altogether. The two hinder molars of *Gymnura* are similar in form to the first molar. The molars of all other Insectivora are constructed on the same type as those of *Gymnura;* and they may be regarded as a series of three more or less specialized structurally "carnassial" teeth, the degree of specialization varying greatly from *Condylura cristata*,—in which both the original outer cusps are of the same height and equally pointed, so that there is no distinction between the "carnassial" and the "tubercular" portion,—to *Centetes*, in which the heel is very short and very low.

Of the Eocene Carnivora our knowledge of the lower teeth of *Arctocyon* is very imperfect. *Palæonictis*, as well as *Didymictis*, have four premolars and two molars on each side, as in *Viverra*. *Cynodon* and *Uintacyon* have each one molar more, as in *Canis*. *Uintacyon* has, besides, one premolar in excess. There is one very important peculiarity common to these forms. In the existing Carnivores, in the lower, as well as in the upper, jaw, only one tooth is differentiated as a "carnassial"; if it is followed by any other teeth, these are structurally strictly "tuberculous," as they are functionally true grinders. But in the genera just mentioned, the second molar (and in the case of *Uintacyon*, the third also) is the exact counterpart of the first. In *Palæonictis*, both the molars are composed of three pointed cusps in front, and a "heel" behind, the back molar, however, being smaller, and, so to say, less "carnassial" than the first. *Didymictis* of Cope agrees so closely with *Palæonictis*, in the number as well as the form of the teeth, that the former may be conveniently affiliated with the latter. In *Cynodon*, the second molar is proportionately much smaller than the corresponding tooth in *Palæonictis;* nevertheless, as in the latter, it is a miniature of the first molar. M. Gaudry, remarking on this feature of the molars in *Palæonictis*, says, that it is not met with amongst the Placentals, and that it is peculiar to the Marsupials.[1] He compares the teeth in question to those of a species of Dasyure. But in this genus the second molar is larger and better differentiated than the first; whereas, it is just the reverse in *Palæonictis*. The resemblance of the molars of *Palæonictis*, or of the first two molars of *Cynodon*, to the corresponding teeth of some Insectivores, as, for

[1] *op. cit.* p. 19.

instance, *Glisorex ferrugineus*, is striking; at the same time such a view would not be open to the objection just raised, for in the Insectivora the molars very generally decrease in size and differentiation from the first to the third. *Amphicyon* has seven molars on each side like *Cynodon*; the lower carnassial is well specialized, and the back molars assume the normal "tuberculous" form.

Exceptional as the molars of *Palæonictis, Cynodon*, and *Uintacyon* are, those of *Proviverra, Hyenodon, Pterodon, Amblodonus, Stypolophus*, and *Oxyæna*, are doubly exceptional. In these eight genera, to the peculiarity of a succession of carnassials, is added that of increase in differentiation, and very generally also in size, from the homologue of the normal flesh-cutting tooth, to that of normally the most "tuberculous," and generally the smallest molar. In *Proviverra*, the three molars increase rapidly in size from the first to the third; each is composed of three pointed cusps and a horizontal "heel." And it is interesting to note that the first molar, in which the primitive antero-external and the accessory cusp in front are the least differentiated, has the "heel" best developed. In the last molar both these cusps are developed in the form of a blade, somewhat as in *Hyenodon*, and the "heel," at the same time, becomes most insignificant. The second molar beautifully presents an intermediate condition. The *Stypolophus* of Cope differs but slightly from *Proviverra*, and I propose to incorporate the former with the latter. *Oxyæna* differs from *Proviverra* only in having two molars instead of three. In *Amblodonus* the first two molars are subequal, and the last molar is a little smaller. But the latter is the most trenchant and best differentiated, the blade being very much like that of *Hyenodon*. If in each of the three molars of *Proviverra* the posterior and inner denticule (the representative of the original antero-internal cusp) be entirely suppressed, the anterior accessory cusp better developed, so as to form with the primitive antero-external cusp a blade-like tooth, and the "heel" correspondingly reduced, we would have as a result the molars of *Pterodon*. The step from *Pterodon* to *Hyenodon* is very easy. If in the former the teeth became more trenchant, the anterior accessory cusp still more differentiated, and, as a necessary consequence, the "heel" all but non-existent, we would have the teeth of *Hyenodon*. This progressive modification from *Proviverra* to *Hyenodon* is not simply a matter of speculation. In America remains of *Proviverra* have been met with in beds which are homotaxial with the Woolwich and Reading beds of England and the "Lignites du Soissonais" of France. In Europe *Proviverra* has been found associated with *Pterodon* in Middle Eocene deposits of the same age as the Bracklesham Series of the Hampshire basin. *Hyenodon* appears at the commencement of the Upper Eocene (or Oligocene) Period, being first met with in the Hordwell beds (Barton Clays). Both *Proviverra* and *Pterodon* die out at the commencement of the Miocene Period. *Hyenodon* held out much longer, living into the Middle Miocene.

Our knowledge of the teeth of *Patriofelis* and *Sinopa* is very imperfect. We are not much more fortunate with the dentition of either *Mesonyx* or *Synoplotherium*. The upper teeth of none of these genera are known, except the incisors, canines, and two premolars of *Synoplotherium*. They all agree, however, in not having any one tooth in the lower jaw differentiated out as the sectorial; they all have a series of flesh-cutting teeth. But the exact form of these is not yet known.

The nearest approximation to the teeth of the Proviverroid and Hyenodont forms in the group of the Insectivora is presented by *Centetes*, the molars of which are similar in form, slightly increase in size from the first to the third, and are constructed on essentially the same type as the molars of *Proviverra*—there are three pointed cusps in front and a horizontal heel behind; and the step from *Proviverra* to *Hyenodon* and *Pterodon* is an easy one. There is no doubt that the teeth of these two last-mentioned genera have a striking resemblance to those of *Thylacinus*, though there are important points of difference with regard to the form of the teeth, etc. There is, however, one serious objection to the affiliation of the Hyenodonts with the *Didelphidæ*. M. H. Filhol[1] has been fortunate in obtaining several beautifully preserved specimens showing the replacement of the deciduous by the permanent teeth. In the upper jaw four permanent molars (behind the 1st *pm.*) succeed as many milk ones; and in the lower jaw all the teeth of the adult dentition, except the hindermost carnassial, have predecessors; so that according to their development there are, strictly speaking, 5 premolars in the upper, and 6 in the lower jaw. Though such a large number of what must be regarded as false molars is somewhat exceptional amongst the Placentals (certainly among the Carnivores), the deciduous dentition of Hyenodonts is quite unlike what obtains in the *Marsupialia*.

In these, as has been shown by Prof. Flower, only one tooth of the permanent dentition (*pm.* 3) has a predecessor.

(*C.*)—Summary.—The results of this section may be summarized as follows:—

1. That starting from the *Arctocyon*, the most primitive Carnivore known to us, we have two divergent series, one comprising *Palæonictis*, *Amphicyon* and *Cynodon*; and the other, *Proviverra*, *Hyenodon*, *Pterodon*, *Amblyctonus*, *Oxyæna*, and probably also *Synoplotherium*, *Mesonyx*, *Patriofelis*, and *Sinopa*.

2. That the first of these two series approach in the form of their teeth the typical Carnivora, of which, as we shall try to show hereafter, they were the ancestors.

3. That the second series formed an exceptional group of Carnivores, of which *Hyenodon* was the last and most highly organized form.

4. That the peculiarities in the dentition of the Eocene Carnivores can be most consistently explained by observing the modifications in the dentition of the *Insectivora*.

§ 3.—*Brain and Osteology.*

As a very general rule the brain cavity of the Eocene Carnivores

[1] *op. cit.* p. 169.

was comparatively small. The structure of the brain in the great majority of them, as made out from casts either natural or artificial, presents some singular points of departure from the typical Carnivora. In *Arctocyon primævus*, according to Prof. Gervais,[1] the cerebellum is completely exposed; the cerebral hemispheres are proportionately very small; the olfactory lobes are very well developed, thicker than the anterior part of the cerebral hemispheres, and proportionately longer than in any normal Carnivore. It is only with the Marsupials, remarks the learned anatomist, that the brain of the *Arctocyon* could be compared. The brain of *Proviverra* is not much more highly organized; and this is what chiefly reveals to M. Gaudry its Marsupial affinities.[2] But I have only to quote the following from Prof. Huxley's description of the brain of such a familiar Insectivore as the Hedgehog, in order to show that the low type of brain in *Arctocyon, Proviverra,* etc., has a parallel also amongst the Placentals:—

"The brain of the Hedgehog is remarkable for its low organization. The olfactory lobes are singularly large and are wholly uncovered by the cerebral hemispheres; which, on the other hand, do not extend back sufficiently far to hide any part of the cerebellum. Indeed they hardly cover the corpora quadrigemina. Only a shallow longitudinal sulcus marks the upper and outer surface of each hemisphere."[3]

The brain of the *Hyenodon* is much more highly organized, and approaches the condition met with in the higher Carnivora, such as the *Felidæ.*[4] This confirms in a remarkable manner the conclusion to which I was led at the end of the last section, viz. that *Hyenodon* was the most differentiated form in the peculiar group of Carnivores, the first link of which as yet known to us is *Proviverra.*

The only important points in the osteology of the skull of *Arctocyon* which have been supposed to indicate its Marsupial connexion are the lateral expansion of the zygomatic arches, and the presence of a pair of *foramina* in the hinder portion of the palate noticed by Prof. Gervais. The zygomatic arches are not proportionately wider in *Arctocyon* than in the Hedgehog; and the palatal vacuities, which would seem to have afforded Gervais and Gaudry incontrovertible evidence of the Marsupiality of *Arctocyon*, are by no means uncommon among the Insectivores (e.g. *Tupaia, Erinaceus,* etc.)

Vacuities in the posterior portion of the palate have not been detected in any other Eocene Carnivore. All the genera (*Hyenodon, Pterodon,* etc.) which have been supposed by M. Gaudry and other anatomists to belong to the Didelphia, or retain traces of their Didelph origin, agree in not having certain peculiarities which are essentially characteristic of a Marsupial skull. In none is the jugal so large as to reach the lachrymal in front, and pass beneath

[1] "Nouvelles Archives du Museum d'Histoire Naturelle de Paris," vol. vi. 1870, p. 147.

[2] *op. cit.* p. 32. The brain of *Oxyæna*, as well as of *Stypolophus*, was similar to that of *Arctocyon* and *Proviverra* (Cope, *op. cit.* pp. 72 and 107).

[3] "The Anatomy of Vertebrated Animals," p. 447.

[4] Gervais—"Nouvelles Archives," 1870, p. 127.

the zygomatic process of the squamosal behind. In *Hyænodon leptorhynchus* (the only species of which the skull is well preserved) the malars are absent; but they were evidently short, as inferred by De Blainville. In none of the Eocene Carnivores the angular process of the mandible is inflected inwards. In none the perforation of the lachrymal is upon, or external to, the anterior boundary of the orbit. The pterygoid processes are well developed, and generally considerably elongated posteriorly, especially in *Cynodon* (subgenus *Cynodictis*). In the Marsupials, on the other hand, these processes are invariably small and filiform. The form and arrangement of the facial bones too are generally very different from what obtains among the Didelphia. Even in *Hyenodon*, the constitution of the facial portion is such, that M. Filhol remarks, that "elle est absolument différente, et ne me semble permettre aucune rapprochement entre le carnassiers phosphorites [*Hyenodon*] et celui d'Australie."[1]

The humerus of *Arctocyon* is very stout and strong, with the deltoidean crest very largely developed, and indicates, as suggested by De Blainville, an animal which made great efforts with the anterior members either for digging or for swimming. It has been compared to the humerus of the Badger by De Blainville, and to that of *Phascolomys* by Gervais.[2] But if *Arctocyon* resembles this Marsupial in the structure of the arm, the forearm of the former is very different. In the *Didelphia* the upper end of the radius is invariably small and rounded. But in *Arctocyon*, as well as in *Hyenodon*, *Pterodon*, *Synoplotherium*, etc., this part is broad and transverse, as in the normal *Carnivora* and *Insectivora*. The ulna of *Arctocyon*, thick, distinct, prolonged into a long olecranon, is very much like that of the Badger, except, perhaps, that the former was less apophysed than the latter. The humerus of *Hyenodon*, besides the great development and inferior prolongation of the deltoidean crest, is remarkable for the co-existence in it of a supracondylar and a large supratrochlear perforation, as in *Mydans* (one of the Subursidæ). The arm and forearm of *Amphicyon* have the strongest affinities with the corresponding bones of the Bear. In *Cynodon* too these bones are very much like those of the typical *Carnivora*.

In the manus of the European genera, so far as known at present, the scaphoid and lunar were united, as in the typical *Carnivora* and some *Insectivora*. The scapho-lunar of *Amphicyon*, described by De Blainville in *A. major*, differs but slightly from the corresponding bone of the Bear. In a species of *Pterodon* in the collection of the British Museum I observed the coalesced scapho-lunar. In *Cynodon* too these bones are united. With regard to the American genera, we have no information concerning the scaphoid and lunar, except in the *Synoplotherium* of the Bridger formation, in which Prof. Cope says that these bones "appear to be distinct." It would be, however, too premature to generalize from this doubtful case of an extremely aberrant form even amongst the exceptional Carnivora of the Eocene Period. With one or two probable exceptions, the manus was provided with five digits; and the movement was either quite

[1] *op. cit.* p. 190. [2] Nouv. Arch., etc. 1870.

plantigrade or subplantigrade (except, perhaps, in the case of *Mesonyx*). So far as known at present, there is nothing very exceptional in the structure of the pelvis or the hind limbs of the European genera. But in the American forms Prof. Cope has described some curious points of departure from the typical *Carnivora*. In all the New Mexican genera, "the ilium has a well-marked external anterior ridge. The ilium has therefore an angulate or convex external face, as in *Insectivora* and *Marsupialia*, and does not display the usual expansion in a single plane of most of the Placentals." But the strong tuberosity present in all the genera in the position of the anterior inferior spine is found only in certain Insectivores and Lemurs amongst existing Mammalia. In *Ambloctonus* and *Didymictis*, the femur supports a third trochanter. This is never the case in the *Marsupialia*. In certain *Insectivora*, on the other hand, such as the Hedgehog, the third trochanter, though rudimentary, is quite distinct.

As a very general rule, the hind-foot, like the manus, was pentadactyle, and plantigrade or subplantigrade. Prof. Cope has described a curious mode of tibiotarsal articulation in some of the American genera. The astragalar articular face of the tibia in these "is not divided into two oblique fossæ by 'a rounded crest which corresponds to the groove of the superior pulley-shaped face of the astragalus.' It is uninterrupted, and more or less oblique in the transverse direction; always so at the posterior border . . . . The astragalus . . . . . . presents an open angle upward, which separates the superior from the oblique internal face. The superior plane is flat, but is interrupted on the posterior side by a groove."

In the genus *Synoplotherium* Prof. Cope found "one of the claws to be broad and flat so as to be subungulate." He has also found a similar ungual phalange in a New Mexican species of Carnivore.

"The flat claws of some of the genera," remarks Prof. Cope, "tend to obliterate the distinction between the Unguiculate and Ungulate series, but they are not present on all the digits of all the species."

M. Gaudry describes an axis vertebra (supposed by him to belong to a Hyenodont animal), of which the spine is highly elevated; its summit, instead of being sharp (as in the *Carnivora*), is depressed, broad and flat. He compares it to the corresponding vertebra of some *Didelphia*. But, as noticed by Prof. Huxley, its form is exactly similar to that of the axis of some Insectivores, such as the Hedgehog.

It may be generalized from the form and number of the caudal vertebræ, discovered in some of the forms, that all the genera had a long and large tail.

REVIEWS.

I.—Memoirs of the Geological Survey of England and Wales. The Geology of the Neighbourhood of Colchester. By W. H. Dalton, F.G.S. 8vo. pp. 24. (London, 1880.)

THE tract described is embraced in Quarter Sheet 48 S.W. of the Geological Survey Map. The London Clay extends over the whole district, covered in one or two places by remnants of

Red Crag, and in certain areas by superficial (Glacial and Post-Glacial) deposits. The most interesting portions of the work are those referring to the so-called Post-Glacial Beds. It is perhaps unfortunate that this term has been used for deposits yielding remains of *Bison*, *Elephas antiquus*, *E. primigenius*, *Felis spelæa*, *Hippopotamus*, *Rhinoceros*, etc.; for these forms are so distinct from those which are known to have inhabited this country in Post-Glacial times. It must, therefore, be understood that the term is used to signify that the deposits are newer than the Boulder-clay of the district. "Post-Glacial" Beds are described near Marks Tey, Lexden, Colchester, Clacton-on-Sea. An Appendix gives records of Well-sections, and Lists of Fossils revised by Mr. Etheridge. The work has been edited by Mr. Whitaker.

II.—The Fossil Fuels of Italy, and their Economic Importance. By Chev. W. Jervis, F.G.S., Keeper of the Royal Italian Industrial Museum at Turin. Dei Combustibili Minerali d'Italia, e della loro importanza economica, etc. 8vo. pp. 89. (Turin, 1879.)

THIS account of the combustible minerals of Italy formed part of a long series of Lectures given by the author in 1879 at the Turin Museum on mineral fuel in general—from peat to anthracite and graphite—showing the slow and regular elimination of certain gaseous compounds contained in wood, leaves, grasses, and such-like vegetable substances, and the various phases of incomplete putrefaction in presence of the air and under water. The influence of pressure,—the lacustrine and littoral accumulations of organic matter,—the function of mechanical impurities, usually regarded as the ash of fuel, but distinct from the small quantity of real *ash* natural to the vegetable organism,—the animal origin of some fuels—were among the subjects treated of; but these were not included with the technology, topography, and geology of the fossil fuels of Italy, which have alone been chosen by the publishers for this issue.

Modest in size and pretension, this little book contains much that is of interest and useful, in a succinct form. After a general account of peat, lignite, various kinds of coal, anthracite, graphite, and diamond, the Palæozoic coal of the Alpine region of Italy is described as occurring in 20 communes belonging to the Provinces of Cuneo, Turin, Vicenza, Belluno, and Udine; mostly in the first two and the last.

In the Apennine region coal occurs in six communes of the Provinces of Genoa and Florence; and in Sardinia at Seui (Cagliari).

The Palæozoic coal of Italy is referred by Jervis to the Lower Carboniferous; and to this stage he also thinks that the coal of Toulon and Corsica, on one side, and that of Carniola and Styria, on the other, also belong.

The Mesozoic coal of the Alpine region near Verona is mentioned; and the Tertiary lignites of the Alpine region on the Tanaro, and at Leffe (Bergamo), Monte Bolca and Valdagno (Verona and Vicenza), Zovencedo and Mure (Vicenza), Soligo (Treviso), and on the Tagliamento (Udine), succeed. Then come the lignites of the Apennine regions, especially on the Rubicone (Forli), of Agnana (Calabria), Cadibona and Sarzana (Genoa), Ghivizzano (Lucca), Upper Arno Valley, and others in the districts of Florence, Pisa, Grosseto, and Sienna; also the lignites of Sardinia and Sicily. In Italy 281 communes of 46 Provinces yield lignite.

The frequent and important peat-beds of the Alpine and Apennine regions are noticed in much detail. Peat occurs in 198 communes of 29 Provinces in the Kingdom of Italy.

To geologists and others interested in Italy and its mineral products, some other works by Signor Gulielmo Jervis are of great utility,—namely, his "Subterranean Treasures of Italy" ("I Tesori sotterranei dell' Italia"), and his "Guide to the Mineral Waters of Italy" ("Guida alle Acque Minerali," etc.).

They have been complimented with "Honorable Mention" and a prize in Paris and Rome. The author's English work "On the Mineral Resources of Central Italy," treating especially of the mines and marbles, is almost out of print now. Signor Jervis is careful in statement of facts, and bold in his expressed views. He warns his readers of the fallacy of referring the increase of temperature in springs to *central* heat. He does not accept the volcanic origin of the boracic-acid lagoons of Central Italy. He refers the "gabbro rosso" of that region to a sedimentary origin; and separates it from the "gabbro" of the Germans, or euphotide. The non-diallagic serpentine he regards as having been derived in many cases from a metamorphosis of the diallagic variety. The gold of Northern Italy, found in the beds of certain rivers, he traces to its source in the pre-Palæozoic rocks of the Alps, where it occurs in minute quantities mechanically mixed with pyrites. T. R. J.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 14, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On a new Theriodont Reptile (*Cliorhizodon orenburgensis*, Twelvtr.) from the Upper Permian Sandstone of Kargalinsk, near Orenburg, in South-eastern Russia." By W. H. Twelvetrees, Esq., F.L.S., F.G.S.

The above measures are cupriferous and rest on limestone with Zechstein fossils. Associated with the remains of Saurians and Labyrinthodonts are *Calamites*, *Lepidodendron*, *Aroides crassispatha*, Conifers, and a *Unio*. The specimen noticed in this paper is apparently the dentary part of the left mandibular ramus, with the crowns of a canine, an incisor, and ten of the molars. The author describes the characteristics of these and the mode of implantation in the jaw, which accords with that described by Prof. Owen in *Titanosuchus ferox*. The characters of this specimen resemble those of the genus *Rhopalodon*; but as there are some marked differences, the author proposes to name it *Cliorhizodon orenburgensis*.

2. "The Classification of the Tertiary Period by Means of the Mammalia." By Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S., Professor of Geology in Owens College.

The author, after some introductory remarks on the value of Vertebrata and Invertebrata in classification, pointed out that the Mammalia become of especial value in the Tertiary period as undergoing more rapid change than the other classes, from their being, as it is happily termed, *en pleine évolution.* He discussed the characteristics of each of the great periods, as defined and limited by their Mammalia, pointing out that throughout the Eocene these frequently exhibit relations more or less marsupial. Indeed, it is not till the close of the Lower Miocene that the traces of this relationship are lost. In the Middle Miocene, *Sus*, *Cervus*, *Antilope*, *Felis*, *Lutra*, and *Castor* appear for the first time, and the higher Apes were present in European forests. In the Upper Miocene *Camelopardalis*, *Gazelle*, *Hyæna*, and *Hystrix* appear. During the Pliocene several important genera disappear from the world or from Europe—among the latter the Apes, at the close of the Upper Pliocene. Oxen, Horses, Bears, and Elephants appear. Great changes took place in the Pleistocene; seven species survived into it which are now extinct, and of new comers there were fourteen living and seven extinct species. *Cervus megaceros* is the sole survivor from the Pleistocene to the prehistoric period which has since become extinct. The paper concluded with some remarks on the latter part of the first and the second period, which, however, as forming the subject of previous notices, was treated more briefly. The author remarked that a study of the development of the Mammalia renders it hopeless to expect to find Man in the Eocene or Miocene, and improbable in the Pliocene.

II.—April 28, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.

The following communications were read:—

1. "Description of Parts of the Skeleton of an Anomodont Reptile (*Platypodosaurus robustus*, Ow.) from the Trias of Graaff Reinet, South Africa." By Prof. Owen, C.B., F.R.S., F.G.S.

The author referred to certain Triassic reptiles from South Africa, already described by him, as showing certain resemblances to implacental Mammals. Another still more interesting indication of such resemblances is furnished by some remains from Graaff Reinet received from Mr. E. J. Dunn. These consist of some thoracic vertebræ with portions of ribs, a sternal bone, a scapula, and a right humerus, found imbedded in one mass of rock, and of a femur and phalanges, and a pelvis in another mass.

The author described these bones in detail. The vertebræ were said to agree most nearly with those of *Dicynodon* and *Oudenodon*. The supposed sternal bone is of a rounded hexagonal form, and is regarded by the author as the anterior bone of the sternum proper, which is usually unossified in recent lizards, but well ossified in *Ornithorhynchus*. In the scapula also the author pointed out resemblances to that bone in *Ornithorhynchus*. The humerus in its general porportions, and especially in the great development of its ridges, was also shown to resemble the same bone in the Monotremes. The ungual phalanges were described as broad and obtuse, probably constructed to bear claws adapted for digging, as in *Echidna*; the femur also resembles that of the last-named animal.

The author remarked upon these approximations to the Monotrematous Mammalia, in allusion to which he proposed the name of *Platypodosaurus robustus* for this animal, the humerus of which was $10\frac{1}{2}$ inches long and nearly 6 inches broad at the distal end. He also alluded to the interesting problems opened up by the study of these South-African reptiles in connexion with their possible relationships to the low implacental Mammalia of New Guinea, Australia, and Tasmania.

2. "Note on the Occurrence of a New Species of *Iguanodon* in the Kimmeridge Clay at Cumnor Hurst, three miles west of Oxford." By Prof. J. Prestwich, M.A., F.R.S., F.G.S.

The pit in which the occurrence of *Iguanodon* was discovered was worked in Kimmeridge Clay at the foot of an outlying mass of Lower Greensand forming an isolated hill. The Portland beds, which occur at Shotover, are here wanting. The bones were found in a thin sandy seam intercalated in the clay, and traversing the hill at least 15 feet below the Greensand. The skeleton was probably almost entire; but, as attention was not directed to it until nearly all the clay had been removed, many bones were lost and others injured. Several vertebræ of *Ichthyosaurus* were found in the same seam, and the characteristic *Gryphæa virgula* occurred in profusion. The clay above and below contained fossils of Kimmeridge types. The author stated his opinion that land probably lay to the south-west of the Oxford district.

3. "On *Iguanodon Prestwichii*, a New Species from the Kimmeridge Clay." By J. W. Hulke, Esq., F.R.S., F.G.S.

In this paper the author described in detail the remains of *Iguanodon* found at Cumnor Hurst in the Kimmeridge Clay, as described in the preceding paper. They illustrated nearly every part of the skeleton of an immature individual, adding greatly to our knowledge of the variation of the vertebræ in the several regions of the vertebral column, and of the structure of the head and hind limbs. In the latter, both the tibia and the fibula articulate (as in embryo birds) with the *os calcis*, which bone is now first identified in *Iguanodon*. The sacral vertebræ were only four in number, and the species further differed from the Wealden *Iguanodon Mantelli* in the simpler character of the serration of the teeth, of which the lamellæ are not mammillated, and in having the vertebræ of the trunk and sacrum not so compressed. The author named the species *Iguanodon Prestwichii*.

CORRESPONDENCE.

DR. CROLL'S EXCENTRICITY THEORY.

Sir,—In your last number Mr. Searles V. Wood advances what he considers to be "the conclusive objection" to Dr. Croll's theory of excentricity as a cause of the glacial epoch, viz. that North America was glaciated further south than Europe, in proportion to its *present* difference of winter climate, while Dr. Croll admits his theory "to be baseless unless there was a *complete diversion* of the warm ocean currents from the hemisphere glaciated."

I do not myself remember that Dr. Croll ever made such an admission, and it is certainly not necessary for the application of his theory. But whether there was a *partial* or a *complete* diversion of the Gulf-stream from the coasts of Europe, the result anticipated by Mr. S. V. Wood—a complete *similarity* in the extension of ice over the two continents—was not be expected, *because they are subject to very different conditions*, independently of the action of ocean currents.

Europe is interpenetrated by seas having a southward opening, while the mass of land in Western Europe is trifling compared to that of North America. Transfer the Mediterranean to America and you have a sea entering south of Cape Hatteras, and extending quite across the continent to the Sierra Nevada of California, with northward branches reaching to Lake Huron! The influence of such a sea receiving the waters of one of the largest tropical rivers (the Nile), together with the broken form of the western coast of Europe and the narrowness of the land, must be alone sufficient to give Western Europe an insular climate as compared with Eastern America. But at the same time we have on the American side conditions tending in the very reverse direction. The enormous ice-bearing masses of Greenland and Grinnell's Land immediately to the north and north-east, and the Highlands of Labrador in the latitude of the Germanic plain, combined with the great *cul-de-sac* of Hudson's Bay, to receive icebergs from the north, and pile them up in its southern inlet, almost in the latitude of London, must have tended to lower the climate of North America during the Glacial epoch as much as the Mediterranean and the Bay of Biscay must have ameliorated that of Europe.

These causes of difference of climate depend on broad geographical facts, which we have every reason to believe existed during the Glacial epoch as they do now, and they appear to me amply sufficient to account for the 10° or 12° further southward extension of the ice in America than in Europe, even if the Gulf-stream were "completely diverted." But I do not believe it was completely, but only partially diverted and also diminished in intensity, and it therefore still exerted *some* differential action on the climates of the opposite coasts of the Atlantic. I would also point out that the difference between the latitudes of points with the same *winter* isothermals in West Europe and East America averages about 20°, which is much greater than the difference of the limit of glaciation in the countries, and this would show that some equalizing effect *was* produced by the diminished and partial diverted Gulf-stream, as Dr. Croll's theory requires.

Having recently been subjecting the whole of the evidence on the subject of "geological climates" to a careful examination, I may state, that I have arrived at an important modification of Dr. Croll's theory, which will, I believe, obviate the chief objections that have hitherto been made to it. The subject will be fully discussed in a volume I am now engaged in printing.

CROYDON, *April* 18*th*, 1880. ALFRED R. WALLACE.

PERMIAN ROCKS.

SIR,—The investigation at present occupying the attention of Messrs. Teall and Wilson is, I believe, one connected with a most important geological question,—a question that hereafter must engage more attention than it does at present. These inquirers however are in advance of their age, and have much up-hill work before them. Nevertheless I suspect that hereafter geologists will have to allow that the rocks of the so-called "Permian Formation," are only "passage-beds" between Carboniferous and Triassic formations,—palæontologically allied to the first, but stratigraphically to the second. Before this is accomplished, a great deal of work will have to be done in collecting and arranging in tabular form all the evidence in connexion with the rocks of this so-called formation; and thus prove the *hiatus* said to exist in different places to be imaginary.

In Ireland there are only small exposures of Permian rocks, yet they appear to be very important, as they point to the true character of the rocks that have been elevated into a "formation." They are as follows:—

Permians of Armagh.—These rocks are in the vicinity of Armagh town, and apparently are the conglomeratic basal beds of the Trias. There is no evidence to prove an unconformability between them and the Trias.

Permians of Benburb.—These are exposed in the Blawater valley on the nearing of the counties Tyrone and Armagh. They undoubtedly belong to the Carboniferous, as they lie conformably on a true Carboniferous limestone, while in the centre of the group is a bed carrying typical Carboniferous fossils.

Permians of the Lagan Valley.—Those near Moira are of a somewhat similar type to those of Armagh, and here, as there, seem to be at the base of the Trias; while those at Cultra would have been classed with the associated Triassic beds but that they carry fossils similar to those of the Durham Permians.

Tullyconnell Permians.—These rocks, although apparently belonging to the Trias, carry fossils similar to those in the Cultra beds. In one locality (Templereagh) they are very instructive; here, while sinking a coal-pit, a dolomite 16 feet thick was found, stratigraphically belonging to the Trias, but palæontologically to the Permian. The Permians of Tullyconnell and Cultra, although palæontologically similar, seem to be on different geological horizons; as the first are associated with Keuper Marls, and the latter with Bunter Sandstones. G. Henry Kinahan.

UPPER DEVONIAN IN DEVONSHIRE.

Sir,—In connexion with Prof. Roemer's paper in the April Geological Magazine, it may be of interest to remind geologists of the occurrence of the *Clymenia* limestone at Lower Dunscombe, above the *Goniatites intumescens* stage. The highest bed the Professor appears to have observed at Lower Dunscombe was the flaggy limestone with *Goniatites*. Want of time prevented my collecting from this part, and the short list in my paper is from the thicker-bedded limestone a few feet lower. In the field above, however, which, at the time I examined it, was newly ploughed, there was a quantity of shaly or nodular limestone, full of *Clymenia* (*C. valida* and *C. striata*).[1]

This discovery of the *Clymenia* stage in South Devon is due to Mr. Etheridge, who determined the fossils. Clement Reid.

DESCRIPTIONS OF THE FOSSILS FROM SUMATRA. ADDENDA ET CORRIGENDA.

[See Geol. Mag. 1879, Decade II. Vol. VI. pages 385, 441, 492, and 535.]

I. The fossils, Nos. 1-4, pp. 386, 387, are from the Carboniferous Limestone of Sibelaboe, Highlands of Padang.

II. *Sparganilithes gemmatus*, Pl. X. Fig. 4, is from the shale above the second coal-seam of Soengei-Doerian,[2] Highlands of Padang; Eocene, 2nd stage.

III.—The following twelve fossils are from the Limestone with Orbitoides and Corals at Batoe Mendjoeloe, Highlands of Padang; Eocene, 4th stage, equivalent to stage γ of Borneo:—

Cardita, sp.	Pl. X. Fig. 6.	*Cypræa subelongata*.	Pl. XII. Fig. 3.
Lucina, sp.	,, ,, 7.	*Cerithium*, sp.	,, ,, 4.
Pecten, sp	,, ,, 12.	*Turbo Borneensis ?*	,, ,, 5.
Cidaris, sp.	,, ,, 17.	*Phasianella Oweni*	,, ,, 6.
Conus, sp.	Pl. XII. Fig. 1.	*Trochus*, sp.	,, ,, 7.
Conus substriatellus.	,, ,, 2.	*Prenaster*, sp.	,, ,, 8.

IV. All the other sixty-five fossils are from the marls of the Island of Nias, probably of Miocene (late Miocene) age.

V. The *Cardita Sumatrensis*, Pl. X. Fig. 5, is also from the Nias marls or clays, and not from the clay-bed associated with the coal of the 2nd stage, Eocene.

R. D. M. Verbeek.

PROFESSOR MILNE ON VOLCANOS.

Sir,—When Professor Milne was writing his article on the distribution of Volcanos I happened to say to him pretty much what is contained in Mr. Fisher's letter in your last number. His answer was—"I wish to keep myself from committing the common error of many geologists who know a little mathematics, the error of imagining that I can create a mathematical theory for a phenomenon, when I am only acquainted with part of the cause of the phenomenon. On the supposition that rock is always of the same conductivity, we may find that an isothermal surface is probably one thousand feet

[1] Geol. Mag. Dec. II. Vol. IV. p. 454.
[2] See Geol. Mag. Dec. II. Vol. II. p. 480.

deeper beneath the bottom of the sea than it is beneath the surface of dry land. But the rigidity of rock is not merely a function of temperature; it probably increases if the pressure increases, as we see from all the meagre information in our possession. Thus we know that solid rock probably sinks in melted rock, and that, therefore, pressure raises its melting-point. Again, we know that the interior of the earth is probably at an enormously high temperature, and yet Sir William Thomson tells us that on the whole it is more rigid than glass. I have good reason for believing, therefore, that as the pressure on an isothermal surface beneath an ocean is much greater than on the same surface beneath dry land, a surface passing through all points where the rock is equally rigid or equally strong to resist tensile stresses, and which is the surface I really have to deal with in my paper, would probably be several miles deeper off the coast of Japan than it is directly underneath dry land." In my ignorance I cannot give with sufficient fullness the clear reasoning of my friend; but as what I have given seems to be a suitable reply to Mr. Fisher's letter, I must beg you to insert it, since Mr. Milne is too far away to reply for himself. JOHN PERRY.

SCIENTIFIC CLUB, 18*th May*, 1880.

OBITUARY.

PROFESSOR K. A. L. VON SEEBACH.

BORN AUG. 13TH, 1839; DIED JAN. 21ST, 1880.

KARL ALBERT LUDWIG VON SEEBACH was born at Weimar, August 13th, 1839. When eight years of age, his father, Chamberlain Major von Seebach, placed him at Keilhau, near Rudolstadt, where, under the teaching of MM. Barop and Middendorf, he passed six happy years. In 1853 he returned to Weimar, and entered the Public Gymnasium under the direction of Hermann Sauppe. Here he enjoyed the advantage of good classical teaching, and at home acquired from his father the love of physical science. Major von Seebach had been a special favourite of the aged Goethe, who had given him a small collection of minerals with a catalogue in his own handwriting; this gave the young officer his first impulse in pursuit of science. Goethe's collection, augmented by the father for the benefit of his son, was by the youthful Seebach united to a series of geological and palæontological specimens; the whole of these treasures, at a later period, were presented to the Göttingen Museum. While still at school he wrote his first scientific paper, "The Entomostraca of the Thüringian Trias," which appeared in the Zeitschrift der Deutschen geologischen Gesellschaft (Jg. 1857). His varied attainments proved that scientific investigations had taken a firm hold on his mind; and when leaving in 1858, the highest certificate was bestowed on him by the Governors for his general excellence.

After his exertions at school and his rapid growth, a very wholesome year of mining at Kamsdorf, near Saalfeld in Thüringia, followed. He still further improved his scientific taste by an academic course, and at Easter, 1859, he began to study with Prof. Ferdinand

Römer at Breslau, for whom he possessed a grateful admiration to the last. These studies he continued in Göttingen and Berlin under Prof. Beyrich. In 1862 he wrote a memoir "On the Molluscan Fauna of the Weimar Trias."

After this course of study came scientific travels. First, in company with Professor Römer, he visited the Carpathians, and in 1861 Russia, in 1862 England, in 1863 Sweden.

At the conclusion of his University career in 1863, he was elected Professor Extraordinary of Geology and Palæontology in the University of Göttingen.

After the publication of his "Hannoverian Jura" in 1864, he obtained the title of Professor, and started upon a scientific expedition to Central America, which occupied him a part of 1864-65.

He was incessantly engaged upon the account of this expedition, but it so hindered his professorial labours, that only one preliminary account of the results has appeared. His investigations into the phenomena of volcanos were worthy the journey to Central America, and are well expressed in a letter on "The typical difference in the form and construction of volcanos and their causes." In 1866 he visited the Island of Santorin, and published an account of it in 1867, treating of its remarkable volcanic phenomena. A little later he started various scientific questions in a clear and intelligent form: "The waves of the sea and their geological action" (1872). "Central America and the interoceanic canal" (1873). In June, 1867, he married Berta Sauppe, the second daughter of his former master, the Professor of Philology and Classics in Göttingen. In 1870 Seebach was appointed permanent Professor.

From 1867 he worked at the Geognostic Charts of Prussia and Thüringia, and spent his summer vacation in the field. In 1872 the maps for Worbis and Niederorschel were finished; other completed works await publication. The completion of a new Natural History Museum, in which the geological and palæontological collections formed by far the largest share, was his latest task, and was a subject very near his heart. In the carrying out and executing of the plans he took a most active part. Late in 1877 the building was finished.

At that time the meeting of the German Geological Society was held in Vienna, when, contrary to Seebach's desire, the meeting for the ensuing year, 1878, was fixed to take place in Göttingen. This caused him to work in the draughty unfinished rooms, moving and arranging the collections, a task which he accomplished, but only at the cost of his already heavily overtasked strength.

A winter (1878–79) passed in Portugal, was to restore his health and relieve his bronchitis. The interest excited by a visit to this, as yet, little known land, restored for a time his strength, and renewed his scientific activity. In the spring of 1879 he returned to Göttingen, but only to retire to a couch, from which he was never again to rise.

On January 21st, 1880, he died, leaving a warm and lasting remembrance of his brave and true-hearted nature, which all who knew him will cherish.

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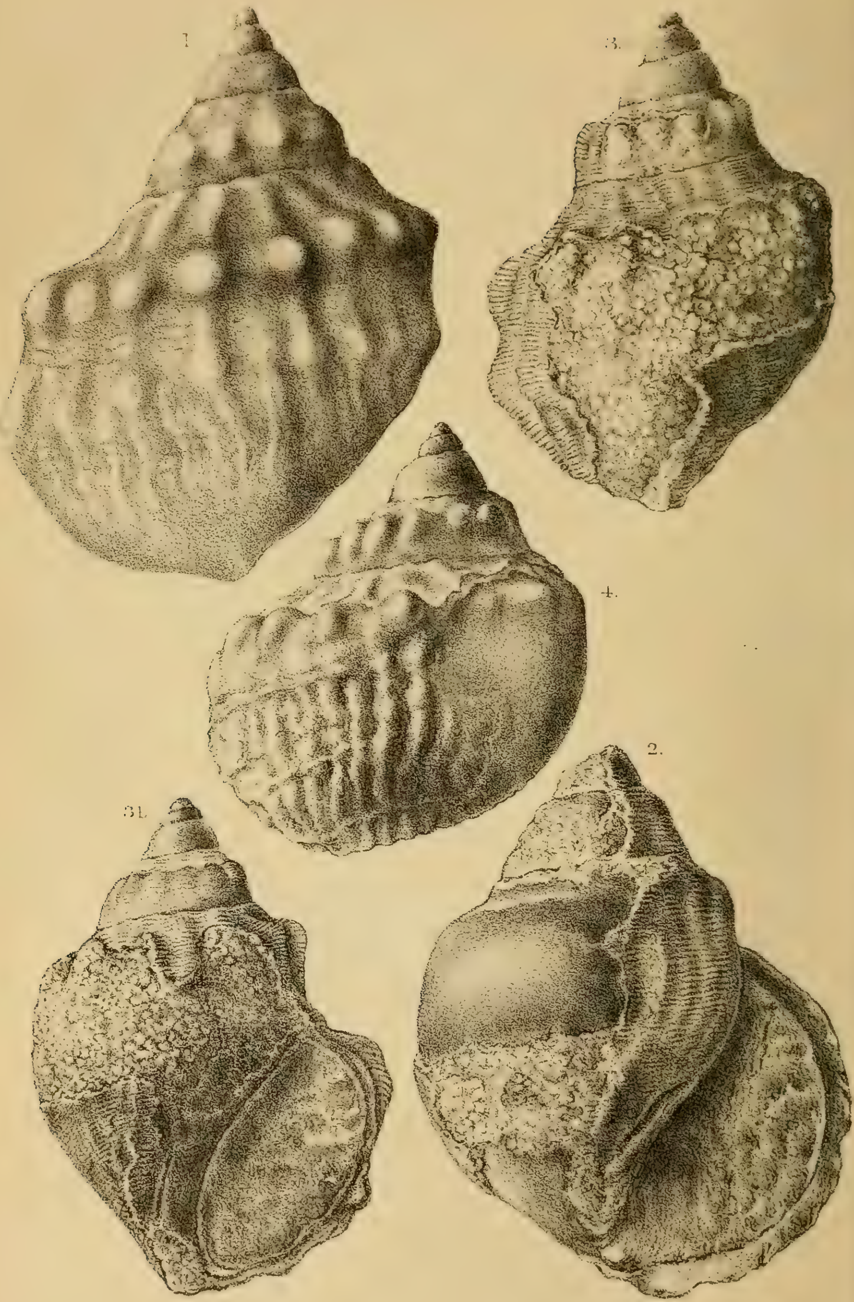

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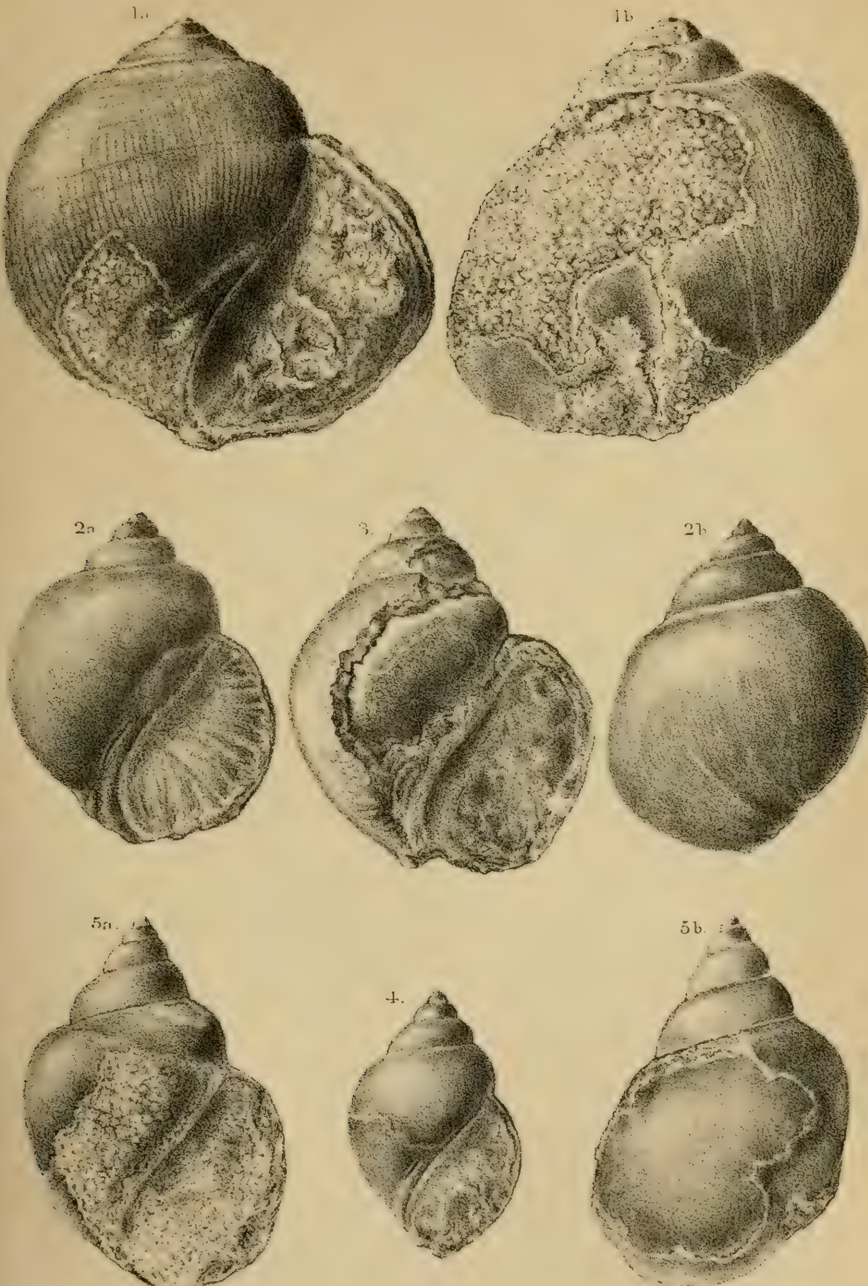

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No. VII.—JULY, 1880.

ORIGINAL ARTICLES.

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

Part II.

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

(PLATES VIII. & IX.)

Genus Purpuroidea, Lycett, 1848.

Whatever may be the precise biological value of this genus or subgenus as distinct from *Purpura*, it forms a remarkable group, limited, according to our present knowledge, both in time and space. Of the conditions favourable to its development we only obtain glimpses here and there. In the Coral Rag of Yorkshire one would say that the genus displays a remarkable tendency to variability within certain limits, so much so that almost every specimen found in anything like a decent state of preservation differs in some point of ornament: hence the extreme difficulty of specific arrangement. One might almost suppose that, like the Ammonite, the genus having worked out the limits of possible change, flourished within a short period only, and speedily became extinct.

D'Orbigny's genus *Purpurina*, with which this one has been confounded by Buvignier, and even by Morris and Lycett,[2] should be confined to a group of much smaller shells if we accept the limitations of Deslongchamps,[3] who breaks up D'Orbigny's genus into *Purpurina*, *Brachytrema*, and *Purpuroidea*.

1.—Purpuroidea nodulata, Young and Bird, 1828. Plate VIII. Figs. 1, 2, and 4.

Buccinum, like *flammeum*, Dillwyn, Young and Bird, Geol. Surv. of the Yorkshire Coast, 1822, plate xi. fig. 3, and p. 242.
Murex nodulatus, Young and Bird, 1828, *op. cit.*, plate xi. fig. 3, p. 244.

Bibliography, etc.—The figure of this very variable species given in the earlier edition of Young and Bird is by no means an unhappy attempt. Though little more than a rough sketch, it is very characteristic of an average of specimens. The figure in the edition of 1828 is inferior. *Buccinum*, too, was much nearer the mark than *Murex*, affording one of many instances that the palæontology as well as the plates of the second edition were inferior to that of the first. In his edition of 1835 Phillips calls this species *Natica nodulata*, Phil., identifying it in his reference column with Young and Bird's shell. The change of genus was unfortunate, and is the more remarkable from the fact that, although imperfect

[1] Continued from the June Number, p. 248.
[2] Mollusca of the Great Oolite, p. 25. [3] Bull. Soc. Linn. Norm. vol. v p. 119.

naticoid casts of this shell are common enough, there must have been plenty of specimens showing the wide basal notch which clearly brings the species within the Siphonostomata. It affords, moreover, an instance, happily rare amongst British palæontologists, when an author, on the strength of having changed the genus, appends his own name to the species.

In 1850 Lycett[1] described three species of *Purpuroidea* from the Great Oolite of Minchinhampton, and these three species are extremely well drawn by Bone.[2] The third of these was identified with the Yorkshire form, and received the name of *Purpuroidea nodulata.* It is quite likely that the learned authors of the Great Oolite Mollusca were unable to obtain decently preserved specimens of our Coral Rag species, or they would scarcely have placed the two under the same specific designation. We owe, however, to Morris and Lycett the recognition that *Murex nodulatus*, Y. & B., and *M. tuberosus*, Sow., should be classed under the new genus *Purpuroidea*, and thus the mistake of Phillips as to the genus was rectified. That *P. nodulata*, M. & L., is more closely related to the Yorkshire shells than are the other two Minchinhampton species none will doubt; perhaps it may be entitled to rank as an ancestor. Of course it must be admitted that where one man sees a species another only sees a variety; but in this case the *general type* of ornamentation (and, to a certain extent, also the form) of the Great Oolite shell differs materially from any of those found in the Coral Rag of Yorkshire.

In 1852 Buvignier,[3] who includes these shells under *Purpura*, takes the opportunity of pointing out the important differences between his Coral Rag species, *P. Lapierrea* (a nearer relation to some of the Yorkshire shells), and the Minchinhampton shell called *P. nodulata* by Morris and Lycett. In 1875 Phillips, in his third edition, avoiding his original error of calling the Yorkshire shell *Natica nodulata*, Phil., fell into the opposite error of referring it to *P. nodulata*, M. & L.

Description.—It is not easy to select a typical specimen. Owing to original variety of form, aided by some difference in mineralization, and varying degrees of preservation, no two specimens are alike. The best plan, therefore, is to give a brief description of each of the three shells selected, pointing out the resemblances and contrasts, and thus obtain a kind of average diagnosis which may serve as a general description.

Fig. 1.—Specimen from the Coral Rag of Langton Wold (*Yorksh. Phil. Soc.*).

Length	77 millimètres.
Extreme width	58 ,,
Length of body-whorl to entire shell	71 : 100.
Spiral angle	78°.

Shell turrited, angular, consisting of five or six whorls; ornaments of the early whorls, if any, effaced. Penultimate whorl provided with about nine stumpy tubercles or studs; suture strongly marked.

[1] *Op. cit.* [2] Plates v. and vi. [3] Stat. Geol. etc. de la Meuse, p. 44.

The upper portion of the body-whorl slopes outwards towards the principal varix or keel, except in the region immediately adjoining the suture. It is deeply ribbed and furrowed longitudinally. These ribs terminate in a similar set of tubercles, on the very prominent keel situated a little above the middle of the shell. The area between this and the second keel of the body-whorl is 20 mm. in length, and the ornaments are indistinct. This lower keel is less nodular, but has a marked effect on the general symmetry of the shell. The body-whorl is thus divided into three distinct areas, and the lowest third is distinguished by a wavy ribbing, which in some cases appears to bifurcate from the faintly-developed nodes. The position of the shallow notch at the base of the shell is fairly distinct in this specimen, the front of which is too much buried in matrix to show the mouth properly. The mineral condition, too, is unfavourable for showing the finer ornaments, if such existed, and this should be borne in mind when making comparisons with the other figures: on the other hand, it is the only specimen I have ever seen with the margins unimpaired.

Fig. 2.—Another specimen from the Coral Rag of Langton Wold (*Yorksh. Phil. Soc.*).

Length (restored)	78 millimètres.
Greatest width (restored)	58 ,,
Length of body-whorl to entire shell	70 : 100.
Spiral angle	80°.

This specimen is not quite so bold as the last, and is also much more imperfect in outline, but has enough of the shell properly preserved to show the well-marked transverse lines which decussate with the more or less wavy ribbing. The effect thus produced, which is almost like basket work, seems characteristic of all the varieties of this species. The mouth is wide, with a flattish base, which causes it to differ from *Natica*; but the portion which should show the notch is broken away, as is unfortunately too frequently the case. The aperture is semi-ovate, wide, and slightly expanded. The inner lip is but slightly curved: it was thick, and originally extended further over the columellar region, but has been partly destroyed in cutting out the shell; this has produced an appearance like an umbilical groove, which, if it existed, must have been very slight.

From the combination of these two specimens the average character of the species may be deduced.

Fig. 4.—Specimen from the Coral Rag of North Grimston (my Collection). This variety, from the imperfect development of the second keel in the body-whorl, has somewhat closer affinities with *P. Lapierrea*, Buv. Yet, if Buvignier's species be correctly figured, the mouth of the North Grimston specimen is very different. Ours is a handsome and striking form, and, should a sufficient number be found, might be raised to the dignity of a named variety. The spiral angle is 79°, being practically of the same value as in the two specimens previously described—an important point of resemblance. There is also the same kind of wavy ribbing, but it is more coarsely

decussated by transverse bands in those portions of this shell which have been preserved. To be perfectly safe, however, similar parts only should be brought under comparison.

2.—PURPUROIDEA cf. TUBEROSA, Sowerby, 1827. Pl. VIII. Figs. 3*a*. & *b*.

Murex tuberosus, Sowerby, 1827, Min. Conch., Tab. 578, fig. 4.

Bibliography, etc.—As far as one can judge from Sowerby's figure, he appears to have described one of the narrower forms of *Purpuroidea* from the "Pisolite at Malton." If we are to refer all the Yorkshire specimens to one specific designation, then Sowerby's name must take precedence of that given by Young and Bird.

Description.—Specimen probably from the Coral Rag of Langton Wold (Leckenby Collection).

Length (restored)	69 millimètres.
Extreme width	47 ,,
Length of body-whorl to entire shell	68 : 100.
Spiral angle	70°.

The above measurements prove that there is an important difference in the dimensions of this and the preceding species. The outline is rather more on the plan of the Minchinhampton species, but the ornaments are entirely distinct. The whorls were probably six in number: the first four are devoid of tubercles, but are marked by fine transverse lines (not shown in the figure). The penultimate whorl slopes outwards towards its keel, below which it falls away at the same angle as the upper whorls; the front part of this whorl gradually shows a moderate tuberculation, which increases with considerable regularity, and finally developes a very prominent tubercle or horn. The body-whorl, like that of the preceding species, is divided into three areas. The uppermost area slopes outwards towards the principal keel. It is ornamented with transverse lines or ridges, having a tendency to arrange themselves in pairs, and is more or less decussated by longitudinal plications and lines. (This kind of minute ornamentation extends over the greater portion of the shell, producing a very pretty effect.) The upper or principal keel is moderately and regularly tuberculated, and finally, like the whorl above, developes one tubercle more prominent than the rest. The second keel is well defined near the outer lip, and moderately nodular, but seems to die out when traced backwards. The anterior third of the body-whorl, as far as we can judge from what is left, appears to have had wavy ribs partially bifurcating from the nodes of the lower keel, though probably the shell became smoother as the columellar region was approached.

The posterior part of the aperture is decidedly contracted, and is more like a *Murex* than is usual with the Purpuroids. The columellar lip is also more curved, and its general outline very different from *P. nodulata*.

Relations and Distribution.—Neither of these two species of *Purpuroidea* can be exactly matched elsewhere. *P. Lapierrea*, Buv., perhaps the nearest relation to *P. nodulata*, occurs in the ferruginous Oolite of Viel St.-Remy, which is about the horizon of the passage-beds of the Lower Calcareous Grit. Buvignier also quotes it from the Coral Rag of St.-Mihiel. No Purpuroid has ever, to my knowledge, been found in any other district of the Corallian Rocks of England, and in Yorkshire all the specimens come from a very limited area in the Coral Rag of the eastern Howardians.[1]

Genus Natica.

This genus is by no means well represented in the Yorkshire Oolites generally. In the Lower Oolites, from the Dogger to the Cornbrash inclusive, the species are very restricted as to numbers, and the individuals are usually of moderate size. There is a small specimen, which may be a *Natica,* in the Bean Collection from the Lower Calcareous Grit of Cayton Bay, but the genus is absent, so far as we know, in the Passage-beds, Lower Limestones, and Coralline Oolite (see Stratigraphical Table in the Introduction to Corallian Gasteropoda). The Coral Rag of Yorkshire is richer in this genus, and I am thus able to illustrate four distinct species.

Whether in the struggle with the synonymy, unusually oppressive in this slightly ornamented genus, I have been tolerably successful remains to be seen. Some of the forms figured approach very closely to species from the Great Oolite of Minchinhampton. In this respect the species of *Natica* in the two formations present a greater similarity than do the species of *Purpuroidea.* On the other hand, whatever *names* we may adopt, most of the *forms* can be very nearly matched with similar ones described by D'Orbigny from the Upper Oxfordian or Corallian.

3.—Natica Buccinoidea, Young and Bird, 1828. Plate IX. Figs. 1*a.* and 1*b.*

Nerita (like *maxima*, Dillwyn), Young and Bird, 1822. Geol. Surv. Yorkshire Coast, pl. ix. fig. 2, p. 244.
Ampullaria buccinoidea, 1828, Young and Bird, *op. cit.* pl. xi. fig. 2, p. 244.

Bibliography, etc.—There can be little doubt that this is the shell intended by Young and Bird; the figure in the earlier edition is slightly the better of the two. The back view alone is given by these authors, and the technical description is not very close. In the earlier edition the species was alluded to as a *Nerita* "from the Oolite, two inches long and of equal breadth. . . . It is a smooth shell, except that the body-whorl is marked with the lines of growth, and has a few faint striæ at the base." In the edition of 1828, the authors, as usual, are less happy in their remarks, but suggest the specific name which I have adopted. It is almost impossible to doubt that they were referring to the species described by me below, and the name given by them, according to the rule of priority, takes precedence of all others.

Phillips does not seem to have noticed the species in any of his

[1] Purpuroidea, sp.—Not figured or described. A specimen distinct from any of the previous forms was found by me in the Coral Rag of Langton Wold. It has an extremely wide aperture, which impinges on the columellar area. The condition of the shell is not favourable for judging of the ornamentation, and I merely draw attention to the existence of a form which may some day be found in a better state of preservation.

Murex Haccanensis, Phillips.—There being no certain evidence that this is a Corallian form, it is not included amongst the Corallian Gasteropods.

editions, and it has thus been neglected by other English palæontologists.

In the Terrains Jurassiques, vol. ii. p. 206, D'Orbigny identifies *Natica grandis*, Münst. (see Goldfuss, A.D. 1844, vol. iii. p. 118; pl. 199, fig. 8), with a shell from the Corallian of the Ardennes, La Rochelle, St.-Mihiel and other localities. This shell is figured in the Atlas, plate 295. D'Orbigny's figures and description tally fairly, though not exactly with the Yorkshire species now under consideration, which, if not absolutely identical with the *N. grandis* of that author's identification, must be viewed as its representative in the Coral Rag of Yorkshire. The species of Goldfuss may or may not be the same; it was found in the Jura Kalke of the neighbourhood of Eichstadt, and described in terms so general as to be applicable to more than one depressed and globular form. Thus Morris and Lycett—Mollusca of Great Oolite, p. 41, pl. vi. fig. 12—record its rare occurrence at Minchinhampton. Their figure represents a shell which can hardly be the same as the Yorkshire species about to be described. To this section of the genus belongs also *Natica globosa*, Rœmer, stated by that author to occur in the Portland Kalke of Wendhausen. It is probably a still more globular species, and must for the present be cancelled from the list of Yorkshire Corallian fossils given by me,[1] and *N. buccinoidea*, Y. & B., substituted.

Description.—The specimen figured is from the Coral Rag of North Grimston (my Collection).

Length (restored)	59 millimètres.
Breadth (restored)	56 ,,
Length of body-whorl to entire shell	84 : 100.
Spiral angle	108°.

Shell globose, depressed, very slightly longer than wide, nearly solid. Whorls four or five in number, the upper ones small and rounded; the body-whorl large and ventricose. The upper whorls, as observed in their present condition, are smooth; the lines of growth in the body-whorl are well preserved and very conspicuous. These decussate with fine transverse lines, and thus produce an amount of ornamentation rather unusual in a *Natica*. Towards the middle of the body-whorl is a slight impression, forming a sort of belt across the shell, but this disappears in the more adult portion, as may be seen on comparing the front and back figures. The aperture is extremely wide; the outer lip was in all probability semilunar, but the outline is now considerably impaired from unequal preservation of the margin. Traces of a thick columellar lip are preserved in the upper part, and there is also to be noted in this region the commencement of a slight groove, which may have been connected in some way with a very slight umbilicus.

Relations and Distribution.—The affinities of this *Natica* have already been partly indicated under the heading of Bibliography. Its contour and the fine transverse markings of the shell clearly connect it with the group of which D'Orbigny's *N. grandis* and *N. Rupellensis* are, in France, the representatives. The Howardian shell seems almost intermediate between these two marked Corallian forms.

[1] Yorkshire Oolites, pt. ii. sec. 2.

Neither in the figures of Römer nor in the lists of Brauns[1] do we find any species from the Corallian of North Germany, which can with any certainty be referred to this one. It is equally absent, as far as I know, from the Corallian rocks of the rest of England, and in Yorkshire has only been found in the Coral Rag of the Howardians, where casts of a large depressed *Natica* are occasionally found and the shell sparingly. It is just possible that some of these specimens might be referred to *N. globosa*, Rœmer, which Brauns places in the Lower Kimmeridge of Hanover, etc.

4.—Natica Clymenia, D'Orbigny, 1849. Pl. IX. Figs. 2*a.* and 2*b.*

Natica clymenia, D'Orbigny, 1849, Prodrome, vol. i. p. 353.
Natica clymenia, D'Orb., 1850, Terrains Jurassiques, vol. ii. p. 201, pl. 292, figs. 7 and 8.

Bibliography, etc.—It is not without considerable hesitation that I have concluded to rank this fossil as above rather than with *Natica intermedia*, M. & L., which it so much resembles in its proportions. The specimen selected is smaller than the usual run of this species, which is the most abundant of the genus in Yorkshire. The large forms have more resemblance to D'Orbigny's figure, and there are some specimens in the Leckenby Collection referred to *N. Clymenia*, which scarcely differ except in size from the shell now figured by me.

Whatever name we adopt for this shell, it is essentially median in its contour and dimensions, and presents features which are intermediate between the depressed and elongated *Naticæ*. It is, therefore, one of those common and average forms which are pretty sure to turn up on several horizons.

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

Length (restored)	47 millimètres.
Width	38 ,,
Length of body-whorl to entire shell	76 : 100.
Spiral angle	88°.

Shell ovate, moderately longer than wide; whorls, five in number, convex, smooth and slightly flattened on the upper margin, but becoming less so in the more adult portion of the body-whorl. Aperture semilunar, moderately wide, columellar lip thick and extended. Slight umbilical notch, which appears to be connected with a rugose furrow on the back of the shell.

Relations and Distribution.—The principal distinction between *Natica Clymenia* and *Natica intermedia* consists in the slightly more sloping character of the whorl in the latter species. D'Orbigny describes his shell as having a strongly marked "flat" on the upper part of the whorl, whilst the specimen figured by me has only a moderate one; the spiral angle and other relative dimensions are very nearly the same in both; but *N. intermedia* is a little less globular in outline.

N. Clymenia is described as an Oxfordian species, and is quoted from Neuvisi in the Ardennes, and from Trouville in Normandy. The Corallian of North Germany is poorer in *Naticæ* than the Coral

[1] Obere Jura.

Rag of Yorkshire, nor does there seem to be any representative of this medium-whorled *Natica* unless it be *N. turbiniformis*, Rœm., as quoted by Brauns. As regards distribution in England, *N. intermedia* is stated to be far from abundant at Minchinhampton. In the Coral Rag of Yorkshire, both of the Scarborough and Howardian districts, the species now under description is the commonest form, if one may judge from casts. It certainly occurs along with *N. buccinoidea* in the great shell bed at North Grimston.

5.—Natica clytia, D'Orbigny, 1849. Plate IX. Fig. 3.

Natica clytia, D'Orbigny, 1849, Prodrome, vol. i. p. 353.
Natica clytia, D'Orbigny, 1850, Terrains Jurassiques, vol. ii. p. 200, pl. 292. figs. 3 and 4.

Bibliography, etc.—This belongs to a group of Oxfordian Naticas described by D'Orbigny (whose figure differs from his description, which consult).

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

The fossil being somewhat imperfectly preserved, and slightly crushed, no measurements are given; but the following obvious points, in which it differs from either of the species already described, may be noted.

The shell is considerably longer than wide; the ratio of the body-whorl to the entire length of the shell is less than in either of the previously described species, whilst the spiral angle is of lower value, indicating a shell which is still median in character, but inclining to the elongated forms. There is no tabulation or "flatting" on the top of the whorls, which slope away regularly from the suture with a kind of droop. The body-whorl is slightly ventricose (unless this appearance is the result of crushing), and the aperture tolerably wide.

Relations and Distribution.—The somewhat ventricose character of the whorl might induce us to refer this to the species from the Great Oolite, where it is described as somewhat rare. The shell under consideration is not exactly either *N. clytia*, or *N. formosa.* (See Morris and Lycett, Mollusca of Great Oolite, p. 42, pl. vi. fig. 10.) More typical representatives of *N. clytia* may be found in the Osmington Oolite, and less vigorous ones in the Lower Corallian beds of the inland counties. No other specimen of this group of Naticas is known to me from the Yorkshire beds.

6.—Natica arguta, Phillips, 1835. Plate IX. Figs. 4, 5*a*. and *b*.

Natica arguta, Phillips, 1835. Geology of Yorkshire, vol. i. pp. 101 and 165 (without figure or description).

Bibliography, etc.—There has always been some difficulty about *Natica arguta*, as may well be the case when a name is applied to a fossil in such a random manner. Phillips refers to Smith's "Strata Identified," where, in the plate entitled "Coral Rag and Pisolite," fig. 2, there is a well-drawn figure of a fossil from the Corallian of the South of England, which Smith, at page 20, calls an *Ampullaria*.

Smith's figures do not quite correspond with the specimens now under consideration, but as these latter are, in a great measure, in the condition of casts, the comparison is not easy. The resemblance to the smaller shell (Fig. 4) is sufficient to connect it with *N. arguta*, and there is the further fact that the specimen (the property of the Yorkshire Philosophical Society) has been so labelled in their Museum.

It is a very marked species, totally different from any of the three previously described, and, as it requires a name, there can be no harm in assuming that *Natica arguta* will fit it. The other specimen (Fig. 5), though so much larger, can hardly be separated.

Description of Fig. 4.—Specimen from the Corallian of Yorkshire (Yorksh. Phil. Soc.).

Length (restored)	37 millimètres.
Width (restored)	23 ,,
Length of body-whorl to entire shell	58 : 100.
Spiral angle	61°.

The state of preservation is not favourable to accurate description, as the substance of the shell is partly dissolved away, yet the general contour cannot be mistaken. Shell ovate oblong, much longer than wide; whorls five or six in number, smooth, rounded, without any flattening of the upper portion, which is rounded off, and then falls away steeply towards the base of the whorl. Outer lip imperfectly preserved; the inner lip shows a moderate callosity, and there is a faint trace of an umbilicus, exposed perhaps owing to the partial wearing away of the inner lip. The character of the aperture, and indeed of the whole shell, is rather like that of the so-called *Phasianellæ* of the Oolites.

Fig. 5.—Specimen from the Coral Rag (?) of Slingsby (Leckenby Collection).

Length (restored)	53 millimètres.
Width (restored)	35 ,,
Length of body-whorl to entire shell	61 : 100.
Spiral angle	62°.

This specimen is in a similar mineral condition to the one just described, the surface of the shell being much thinned away. Though so much larger, the proportions are nearly the same, and, except as to size, the description of one will serve for the other. There is at first sight some apparent difference in the contour of the outer lip, but this is probably due to unequal preservation of their respective margins, the larger shell having been broken away considerably anteriorly, so that this part of the aperture appears less elliptical.

Relations and Distribution.—As the larger specimen is, as far as I know, unique, I shall merely view it as a megalomorph of the form identified as *Natica arguta* (Fig. 4). In the Great Oolite of Minchinhampton, whose Naticas, as we have seen, so closely resemble those of the Coral Rag of Yorkshire, there is nothing with which it can be compared, nor have I yet noticed the form in the Corallian of the South of England, except as a fragment in the *Natica* bed at the top of the Lower Calc Grit near Cumnor. However, *Natica arguta* is quoted by Whiteaves from the Corallian of Oxford.

Our Yorkshire species is evidently near to *Natica calypso*, D'Orb. (T. J. vol. ii. p. 202, Atlas, pl. 292, figs. 9 and 10), which is common in the Oxfordian of Neuvisi in the Ardennes. D'Orbigny observes that at first sight his species has more resemblance to a "Phasianella" than to a Natica, but as he had already described a somewhat similar form which is undoubtedly a Natica, he concludes to place the species named *Calypso* in this genus.

Casts and imperfectly preserved shells of *Natica arguta* occur sparingly in the Corallian of Yorkshire, but the precise locality where they have been found is unknown to me.

Natica cincta, Phillips.—No shell answering to this figure (Geol. of Yorks. pl. iv. fig. 9) has ever been observed by me in any collection from the Corallian beds. I once saw the original specimen under glass at the Leeds Museum, and it impressed me as being more like *Natica Leckhamptonensis*, which has been found in some Inferior Oolite Limestone near Castle Howard Park. Professor Morris had also arrived at a similar conclusion.

EXPLANATION OF PLATE VIII.

Fig. 1. *Purpuroidea nodulata*, Y. and B. Coral Rag of Langton Wold. Back view. York Museum.
,, 2. ,, ,, Another specimen. Coral Rag of Langton Wold. Front view. York Museum.
,, 4. ,, ,, Another variety, with different style of ornaments. Coral Rag of North Grimston. Back view. My Collection.
,, 3*a*. and *b*. *cf. tuberosa*, Sow. Coral rag of Langton Wold. Back and front view. Leckenby collection.

EXPLANATION OF PLATE IX.

Fig. 1*a*. and 1*b*. *Natica buccinoidea*, Y. and B. Coral Rag of North Grimston. Front and back views. My Collection.
,, 2*a*. and 2*b*. ,, ,, *clymenia*, D'Orb., probably from the Coral Rag of Langton or Grimston. Front and back views. Strickland Collection.
,, 3. ,, ,, *clytia*, D'Orb. Coral Rag of Settrington railway cutting. Front view. My Collection.
,, 4. ,, ,, *arguta*, Phil. Corallian of Yorkshire. Front view. York Museum.
,, 5*a*. and *b*. ,, ,, Larger type. Corallian of Slingsby. Front and back views. Leckenby Collection.

(*To be continued.*)

II.—On Some Recent Classifications of Welsh Pre-Cambrian Rocks.

By Prof. T. G. Bonney, M.A., F.R.S., F.G.S.

Two papers, presented by Prof. Hughes to the Geological Society during the last twelve months,[1] call for some comment from myself, as in many respects they controvert, directly or indirectly, opinions which I have expressed before the same Society.[2] In the debates which followed I objected to the imperfect evidence on which these criticisms were founded; and as the author repudiated with some warmth my right to demand that conclusions founded not only on field work, but also on microscopic study, should not be assailed from the former point of view alone, I will venture to state the

[1] Read May 14, 1879, and Feb. 25, 1880.
[2] Quart. Journ. Geol. Soc. vol. xxxv. pp. 309, 321.

reasons why I so did, and intend so to do on any future occasion that may arise. Evidence in the field, doubtless, is sometimes so clear that we need not call in the microscope. No one, however, can assert this to be the character of the rock testimony in the district for some miles on either side of the Menai Straits. Professor Hughes's published sections look very clear; but I may remark, without offence, that they are more distinct on paper than in nature. Further, the questions debated in these papers are exactly those where microscopic study is essential in order to attain to anything like a sure conclusion. I am well aware that mountains must not be looked at through the microscope only—I never have so worked or will so work at any petrological question; but I do assert, after seven years' experience with the instrument, that all conclusions as to the minute constituents, amount of metamorphism, and precise nature of these old rocks, must be thoroughly tested with the microscope before we can accept them. I know from this experience that even well-trained eyes—those I mean of observers versed in the special study of rocks, both with and without the microscope—have been occasionally deceived, when they alone were trusted. Professor Hughes seems to reason (for otherwise his complaint is meaningless) as if the results of microscopic lithology were at present all in uncertainty. Were this the case, years of hard work, by not unqualified observers, would have been lamentably wasted. But though, as all such observers know well, we have yet much to learn, there are many points on which we are certain of our conclusions. What would have been thought, some sixty years since, of any geologist who had insisted on correlating strata "by tracing the great rock-masses in the field" only, without paying any attention to their fossil contents? Yet microscopic lithology is now as important a study, and in about the same position as Palæontology was then.

I may, indeed, even venture to say that the internal evidence of Prof. Hughes's paper leads me to conclude that he is so sceptical of the value of microscopic study as to be quite insensible to considerations which would seriously disquiet most petrologists. To take one example only: we have in N.W. Carnarvonshire, below the Cambrian conglomerate, (1) a granitoid series, (2) a mass of quartz felsites representing old rhyolitic lavas, (3) a group of slates and breccias. Dr. Hicks regards these as three totally distinct series separated by very considerable breaks. I do not feel quite so certain of the great separation of (2) and (3); but Prof. Hughes considers, as he says, that "there is no unconformity visible between the groups, whether we accepted the brackets drawn by Dr. Hicks, or those which I proposed."[1] Further on, speaking of the granitoid rock of Twt Hill, in the lowest part of the series, he says, "It is doubtful whether any specimen taken from the heart of this rock has exhibited clear evidence of a fragmental origin." I suppose, then, this means that Prof. Hughes is not satisfied whether the rock is a granite or a granitoid gneiss. Apparently, however, he does not perceive that in expressing this doubt, he is placed in the following

[1] Quart. Journ. Geol. Soc. vol. xxxiv. p. 682.

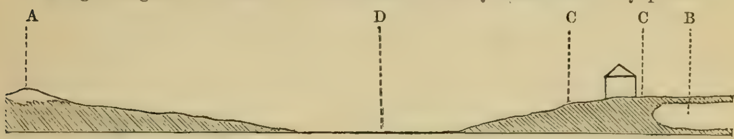
dilemma. If the rock is granite (and that carries some of the rock at Port Dinorwic), how do we explain the immediate succession to it of a rock which is almost a rhyolite; for surely the one would naturally be regarded as connected with the other? If, however, the rock is a gneiss, and simply the lowest member of a continuous series, how do we explain the presence above it of a scarcely altered rhyolite, and above that of a very slightly altered series of slaty and other beds? These are serious difficulties which I think should not have been passed over in silence. It is also rather new to me to find apparently a brecciated aspect in a lava flow used as of classificatory value (p. 687); indeed the author's petrology in this page puzzles me more than once.

I proceed then to deal in detail with some of his criticisms, commencing with the granitoid series which extends from Twt Hill to above Port Dinorwic. There are certain grits and conglomerates exposed on Twt Hill (to N.E. of the summit), at intervals over the tract of granitoid rock towards the N.E. of Carnarvon, and lastly near Careg Goch, above Port Dinorwic: these he holds to be one and the same set of beds, and considers them representatives of the Cambrian conglomerate, brought into their present position by faulting. As to the identity of these beds, I feel now satisfied,[1] but I am by no means able to admit that they can be reckoned with the Cambrian series. At Twt Hill we have in more than one place a fairly continuous section from the true granitoid rock to the conglomerate. Obviously the possibility that the conglomerate might be made up from the granitoid rock, like the *Arkose* of Auvergne, at once presented itself; but though I have twice examined the section, the second time most minutely, I can find no break between the two rocks. Dr. Callaway, after examining the section "inch by inch," confirms my view, stating also that he has found a like conglomerate in a similar position in Anglesey (p. 118). The occasional appearance of fragments of schist among the quartz pebbles, which chiefly compose the conglomerate, doubtless seems to favour the view that it is later than the granitoid rock; still, this evidence is not conclusive, for we do not know the relation of that to the schist. Even if it were proved that this conglomerate were made up from the materials of the rock on which it rests, I could not believe it to be of Cambrian age, because the microscope shows that its matrix, and the finer bands intercalated with it, are much more highly altered than is the case with the Cambrian rocks. Further, I have never yet seen a felsite pebble in this conglomerate or detected a fragment under the microscope, yet that rock abounds in every known exposure of the Cambrian conglomerate; and at Twt Hill itself, within a short distance, there is some

[1] I was formerly inclined, from the evidence of strike and in defect of proof of faults, to place the Careg Goch grits on a lower position than those of Twt Hill, but subsequent examination has shown me that I was misled (partly by defects on the map) on the former occasion, and that there is good reason to infer the presence of faults, which cause the general trend of the beds to correspond more nearly with the line of the ridges.

intrusive felsite.[1] Also, admitting the identity of the Careg Goch conglomerate and grit with that at Port Dinorwic, there is strong evidence to show the improbability of its being later than the felsite. We are here within a very short distance of the edge of a great mass of the latter rock, yet no trace of it even with the microscope can be found in the former. Again, we find this conglomerate at the back of a row of white cottages (at Tan-y-maes), and pick it up in the path in front. This path then descends a rocky step to the side of a little stream. The main mass of the felsite is to be seen at Tan-y-perthi, a very short distance to the N.N.E. The rock, where the path descends, resembles the granitoid series, but on examination proves to be a spherulitic quartz-felsite. Thus, either the conglomerate is dropped into a notch in the felsite, and one portion of this has assumed a very unusual structure, or the spherulitic felsite is intrusive. The annexed diagram will give a general idea of the

Rough Diagram of relation of rocks between Tan-y-maes and Tan-y-perthi.



A Felsite. B Spherulitic Felsite.
C Exposure of Conglomerate and Grit. D Stream.

relations of the rocks. The evidence is not indeed absolutely conclusive, but, as it seems to me, the probability is so great, that the burden of proof lies on the other side.[2]

Proceeding now to the district on the north-eastern edge of this great mass of felsite, I described—in ascending order—(1) a purplish felsitic grit; (2) a series of slates and beds of agglomerate or breccia (Tairffynnon), which terminate with a peculiar breccia, containing much purple slate, which is seen near Cae Seri; then (3) a slaty and agglomeratic series (Bangor Beds of Prof. Hughes). (1) and (2), speaking in general terms, Prof. Hughes suppresses, regarding every grit or rock with felsite fragments as merely Cambrian conglomerate repeated by faults. I confine my remarks at present mainly to the district on the eastern side of the fault, which runs near the line of the Bangor-Carnarvon road. First, then, the above grit—which we trace along the edge of the felsite near Brithdir Farm down towards the valley, pick up on the other side of the fault by the road side, again near a farm-house higher up the hill, and in the road by Beulah chapel—in all these places is in close sequence with the felsite, and is composed of detritus from it. We observe a parallel case in the grit overlying the yellowish felsite on Conway Mountain, and at Diganwy. Is it not, then, rather a singular coincidence that, if this purplish grit be dropped down by a great fault, cutting out all the Bangor series, it should be so completely made up of the detritus of the felsite, and should come for so great a

[1] Discovered by Mr. Tawney.

[2] Certain reasons connected with the proximity of the cottages make it difficult, especially in summer time, to examine the ground inch by inch.

distance in such exact succession? Further, this fault must bend round in a very odd manner, for I have followed the grit to a spot on the steep hill-side overlooking the above-named valley (to me the Survey Map, though less detailed, seems more correct here than that given by Prof. Hughes) where the grit is conglomeratic, as in some places near the entrance to Brithdir Farm. Again, on both sides of the fault, slate appears to succeed the grit. Next I have detected the peculiar agglomeratic rock of Tairffynnon in the field on the top of the hill, to the north.[1] Of the identity of these rocks there can be no doubt, and their structure, full of lapilli of various kinds, and angular fragments of rhyolitic rock (obviously not transported from far, so that they might even be true volcanic deposits), differs very widely from that of any acknowledged Cambrian conglomerate which I have examined. All these I have studied microscopically, and this is one of the questions where such evidence is of high value. Further, I have now traced the peculiar rock of Cae Seri as far as Bryn Dreiniog Farm, perhaps two-thirds of a mile, showing it to be a very persistent bed. This extensive group of rocks—distinguished microscopically by the presence of lapilli and rhyolitic fragments—which we find at intervals over the country[2] about Tairffynnon, Perfyddgoed, Cae Seri, and the ridge on the eastern side of the Carnarvon road as far as the Poorhouse, is far too thick to represent the true Cambrian conglomerate with its rounded pebbles of felsite and miscellaneous rocks, and, as above shown, is too constant in the succession of its varied members to be regarded as that conglomerate repeated by numerous faults. May we not also express a little surprise that these faults should have always so cleverly cut out the characteristic Bangor beds, over this wide area, and have simulated a true succession?

I pass now to the western side of the above-named fault. Here, as described, I can track the felsitic grit for a considerable distance, and have picked up in a little spinney (all but opposite to the junction of the Birthdir lane with the main road) a rock, which I think we may safely regard as representing part of the Tairffynnon series. Afterwards I confess I am utterly perplexed, though I do not find that Prof. Hughes's arrangement helps me more than my own. On his theory we have all the Bangor series cut out. On mine the disappearance of almost everything above the purple felsite grit is no less perplexing. On both, the position of the thick bed of conglomerate, extending from the east entrance of the western tunnel at Bangor to the back of Belmont House, is very anomalous. I find a conglomerate, identical as it seems to me with this, exposed in a byway, near the gate of Gorphwysfa, leading down to a small farm, and on the other side of the felsite. More than once I have asked myself whether this conglomerate may not be identical with that of Brithdir? But whichever it be, its position is most perplexing. This district seems to me to be completely broken up by faults, and far less regular than that on the eastern side of the

[1] On map, about half-way between *l* in Trawscanol and *T* in Tairffynnon.

[2] Part of that which Prof. Hughes admits he has not worked out, Quart. Journ. Geol. Soc. vol. xxxiv. p. 687; the key of the position as it seems to me.

Carnarvon road. Nothing, however, that I have seen, after a careful re-examination (in company with Mr. Houghton) of the whole district, causes me to doubt the general correctness of my original reading. It seems to me not only simpler than that of Prof. Hughes, but also in accordance with the microscopic structure of the rocks; while his requires the identification of rocks which have only superficial resemblances and real differences.

I turn, in conclusion, to Prof. Hughes's recent paper on Anglesey, read before the Geological Society on the 25th of February.[1] Here, after establishing by fossil evidence a very important point, viz. the existence of Tremadoc and Arenig beds in that island, he proceeded to identify what he terms the "gnarled schists" with the Bala series of the mainland—supporting this view by the assertion that the appearance of metamorphism, which had hitherto led every one to bestow the name of schists on these beds, was only superficial and illusory; for in reality they were but slightly altered. To this series he referred the beds on the northern shore of the Menai Straits, in the neighbourhood of Valley and Holyhead, and in other places which I have not visited. Now, I do not pretend to have examined every rock in these two districts; but I have seen a good deal of them, and have investigated microscopically specimens which appear similar to those exhibited at the Society's meeting by Prof. Hughes. For example, as types of the beds in the former district, I have had slices cut from two schists, one from very near the Menai Bridge, another from a quarry just outside that village, on the Beaumaris road; and from two rather chloritic-looking massive rocks, one beyond Glyn Garth on the same road, another by the shore, about 300 yards from the gas works, west of the bridge. Without discussing the details of their mineral composition, it is enough for my present purpose to say that all four are metamorphic rocks in the fullest sense of the word, no certain trace being now left of their original constituents. Again, I have examined the dull lead-coloured or greenish schists from the shore south of Valley station (near the serpentine), and on the neighbouring island reached by Four Mile Bridge; these also, like the others, are true foliated rocks. Again, I have examined a contorted hornblendic schist from near Holland Arms, and a contorted lead-coloured schist collected near to the road going from Holyhead to the Stack Rocks—these are very highly altered. In short, if all these are not as much metamorphic rocks as any mica-schist from Scotland or Switzerland, then I have yet to learn what constitutes that class of rock.[2] With the evidence of the microscope in this direction, and evidence in the field at best (as Prof. Hughes seems to admit) far from strong, we are, I think, justified in refusing to recognize Bala Beds, whether altered or unaltered, in the Anglesey schists.

[1] Published while this paper is passing through the press in vol. xxxvi. of the Quarterly Journal (p. 237). The author, however, has almost suppressed the portion of the paper in which this theory was enunciated (see p. 183 of this Magazine).

[2] Knowing that Mr. S. Allport had also examined some of these rocks, I wrote to ask his opinion. He indorses my view, especially as to the Holyhead schists, which he has recently studied, in the strongest terms.

III.—A Contribution to the Study of the British Carboniferous Tubicolar Annelida.

By R. Etheridge, Jun., F.G.S., F.R.P.S.Edin.

(*Continued from p.* 266.)

9.—*Spirorbis Dawsoni*, sp. nov. (Plate VII. Figs. 26, 27.)

Sp. char.—Tube small, sinistral, narrow, increasing but little in size towards the aperture, very narrow and fine towards the apex; volutions not in the same plane, somewhat raised, with a sunken apex, rather deeply umbilicated on the attached side; section circular. Surface marked with faint, regular, equidistant, transverse ridges, which are more marked along the union of the whorls (or "suture") than on the periphery or back of the last volution.

Obs.—This is one of the few sinistral species of *Spirorbis* we have in the British Carboniferous Limestone. Irrespective of this character, its small size, few volutions, and narrow vermiform tube will mark it as peculiar. It is otherwise distinguished from *S. spinosa* and *S. caperatus* by the style of the ornament, and from *S. ambiguus* by its less robust appearance and absence of the broad back of the latter species. Another character which appears to be peculiar to it is the prominence of the transverse ridges along the inner side of each volution. I have much pleasure in naming this after Dr. J. W. Dawson, who has been, in a great measure, instrumental in bringing to light the true history of these worm-tubes.

Loc. and Horizon.—On the shore, opposite the "Vaults," near Dunbar, in shale over the Vaults Limestone; on the shore to the east of Seafield Tower, near Kirkcaldy, in shale over the Seafield Sandstone, both horizons being in the Lower Carboniferous Limestone Group (*Mr. J. Bennie*).

10.—*Spirorbis* (or *Serpula?*), sp. (Plate VII. Fig. 28.)

Obs.—I have met with a few fragments of free tubes, which appear to be characterized by very strong, and somewhat imbricating, accretion ridges, bearing a general resemblance to those seen in *Serp. scalaris*, M'Coy,[1] but much more numerous, and the tube very much smaller.

Although the fragments are in no way sufficient for description, it is well to mention them in case more perfect specimens are in existence in private collections. They are distinct from *S. Armstrongi*.

Loc. and Horizon.—Skateraw Quarry, near Dunbar, in shale above the limestone; Burlage Quarry, at a similar horizon (*Mr. J. Bennie*).

II.—Genus *Serpulites*, Macleay, 1839.

Serpulites, Macleay, in Murchison's Sil. Syst. 1839, p. 700.
,, ,, Annals Nat. Hist. 1840, iv. p. 387.
,, M'Coy, Brit. Pal. Foss. 1851, fascic. i. p. 132.
Campylites, d'Eichwald, Bull. Soc. Nat. Moscou, 1856, No. 2, p. 408.
,, d'Eichwald, Lethæa Rossica, 1860, i. p. 675.

Gen. char.—Tube smooth, arched, slightly calcareous, glossy; having two small longitudinal tubes at opposite points of the

[1] M'Coy, Carb. Foss. Ireland, 1844, p. 169, t. 23, fig. 29.

circumference (the convex and concave faces of the curve), stronger than the rest of the shell, and prolonged at the posterior end (*M'Coy*).

Obs.—In neither of the papers in which Mr. Macleay proposed the name *Serpulites* was the genus defined, and, so far as I am aware, one of the few definitions which have appeared is that by Prof. M'Coy.

The Chevalier d'Eichwald used the term *Campylites* (non *Campulites*, Deshayes) for such worm-tubes, and ascribed the name to one of the Sowerbys, but I have been quite unable to find a trace of such a genus in any of their writings. It is not given in either Agassiz's "Nomenclator," Bronn's "Index," Morris's "Catalogue," Pictet's "Paléontologie," Geinitz's "Grundriss," Marschall's "Nomenclator," Miller's "Catalogue," or any work of the kind I have been able to consult. Under any circumstances, unless prior to the proposal of *Serpulites* in the "Silurian System," the name *Campylites* will not stand as a substitute for *Serpulites*, for, although the latter was not defined for some years after its first enunciation, its stability is insured by the description and figuring of the type species, *S. longissimus* (Macleay, in Murchison's Sil. Syst. 1839, p. 700).

Prof. M'Coy has shown that, in at least two British species of *Serpulites*, opposite points of the circumference of the tube were thickened, forming two longitudinal ridges, not due to pressure. A similar structure has been shown to exist in a Canadian Silurian species by the late Mr. Billings, viz. *S. dissolutus*, Bill.,[1] in which there is an elevated wire-like margin running the whole length of the tube. *Serpulites dispar*, Salter, and *S. longissimus*, Murch., also possess this raised border. Numerous species of *Serpulites* have been described by authors in which these thickened edges of the tubes have not been observed. It becomes a question, therefore, whether, seeing the occurrence of this character amongst so many species, it will not be necessary to look upon it as of generic value, and, in consequence, eliminate from *Serpulites* all those tubes in which it has not been observed.

The term *Serpulites*, before being employed by Macleay, was made use of by both Blumenbach and Schlotheim in a generic sense. The former described *Serpulites coacervatus* in his "Specimen Archæologiæ telluris terrarumque imprimis Hannoveranarum" as early as 1803,[2] whilst the latter named several species in 1820,[3] but as those of both authors have since been referred to *Serpula*, the name *Serpulites* remains open to be employed in the sense proposed by Macleay.

The following list comprises those *Serpulites* possessing bordered-tubes, or otherwise, with which I am acquainted :—

1. Silurian.

a. With borders.	*b. Without borders.*
Serpulites dispar, Salter.	*Serpulites Murchisoni*, Hall.
,, *longissimus*, Murch.	,, *curtus*, Salter.
,, *dissolutus*, Billings.	,, *perversus*, M'Coy.
	,, *fistula*, Hall.

[1] Canad. Pal. Foss. i. p. 56.

[2] P. 22, t. 2, f. 8. [3] Die Petrefactenkunde, etc., p. 96.

2. Carboniferous.

a. With borders.

Serpulites carbonarius, M'Coy.

„ *membranaceus*, M'Coy.

11.—*Serpulites carbonarius*, M'Coy. (Plate VII. Fig. 29 and 29*a*, *b*.)

Serpulites carbonarius, M'Coy, Synop. Carb. Lime. Foss. Ireland, 1844, p. 170, t. 23. f. 32.
„ „ M'Coy, Brit. Pal. Foss. 1851, fas. i. p. 181.
„ „ Morris, Cat. Brit. Foss. 1854, 2nd ed. p. 93.
? *Campylites carbonarius*, Eichwald, Bull. Soc. Nat. de Moscou, 1856, No. 2, p. 408.
? „ „ Eichwald, Lethæa Rossica, 1860, i. p. 676.
Serpulites „ Young and Armstrong, Cat. W. Scott. Foss. 187, p. 42.
„ „ Etheridge, jun., Quart. Journ. Geol. Soc. 1878, xxxiv. p. 9, t. 1, f. 3.
„ „ Bigsby, Thes. Dev.-Carb. 1878, p. 243.

Sp. char.—Tubes varying in size, elongated, thin, shelly, and from one and a half to three lines in width; ribbon like, but not undulated, intertwined, or contorted; lateral thickened ridges, strong and persistent. Surface shining and smooth, or with very fine, broken, longitudinal striæ.

Obs.—Although by far the most abundant *Serpulites* in the Carboniferous beds of Scotland, and by no means rare in England, is seldom found with the posterior terminal tubes preserved. It is invariably met with in the form of a compressed, or flattened, elongated, narrow tube, usually more or less shining, and very frequently possessing a delicate bluish or bluish-white bloom arising from the formation of an amorphous form of Vivianite, or Phosphate of Iron. I believe these *Serpulites* tubes, like the genera *Lingula, Conularia*, and a few others, to have possessed a fair quantity of horny, or chitinous matter in their composition.

The lateral thickened ridges are usually well shown, and appear to terminate in the posterior bifurcation. The length is considerable, reaching, according to M'Coy, upwards of five inches, although I have not measured one quite so long as this. In certain examples collected from the Wardie Shales of the neighbourhood of Edinburgh I found the surface to be delicately longitudinally striate; instead of simply smooth and plain, as is usually the case.

From *Serpula* (*Serpulites*) *compressa*, Sow., the present species is distinguished by its narrow, elongate form, two lateral thickened ridges, and the absence of the elliptical section of the former. From the next species to be described, *S. membranaceus*, it is less easily distinguished, the points relied upon for separation being more those of degree than actual difference, *S. membranaceus* being, so to speak, much larger, more delicate in structure, less shelly, and, so far as I know, without the two elongated posterior tubes, although it possesses, according to M'Coy, similar thickened margins.

Loc. and Horizon.—*S. carbonarius* occurs in a bed of marine shale in the Wardie shale beds of the L. Carboniferous (Calciferous Sandstone Series), at Woodhall, Water of Leith, near Edinburgh. It is met with in the Carboniferous Limestone Series, both of the east and west of Scotland, in some abundance and at various horizons, being particularly plentiful in shale at Whitfield Quarries, near Carlops, Peebles-shire (*Mr. J. Bennie*). Prof. G. A. Lebour informs me that this species is very characteristic of the 4 fathoms limestone, high up in the Northumbrian Carboniferous Limestone Series, at Denwick, near Alnwick.

12. *Serpulites membranaceus*, M'Coy.

S. membranaceus, M'Coy, Synop. Carb. Foss. Ireland, 1844, p. 170, t. 23, f. 31.
,, Morris, Cat. Brit. Foss. 1854, 2nd ed. p. 93.
,, Bigsby, Thes. Dev.-Carbonif. 1878, p. 243.

Sp. char.—Tube elongate, curved, thin, more or less flattened, and membranaceous. Margins thickened; surface generally wrinkled.

Obs.—Whether this will stand the test of future research as a species is, I think, doubtful. It appears to be separated from *S. carbonarius* by such very trivial characters that I have doubts of its stability. Size apparently is the chief difference between the two, although we have intermediate examples which bridge over the gap. If the size shown by M'Coy's figured example is a constant character, then probably *S. membranaceus* is a good species. On the other hand, we meet with examples of *S. carbonarius* of the typical size covering slabs of shale intermingled with flattened, bi-ridged tubes of much greater dimensions, and of several sizes, and possessing otherwise all the characters of the smaller tubes, which are undoubtedly *S. carbonarius.* If these are parts of one and the same organism, and there does not seem any reason to doubt it, then I do not see why the form, known as *S. membranaceus*, should not represent the largest condition of growth.

A slab of shale in the Museum of Practical Geology from Lesmahagow has such a mass of tubes on its surface. The smallest of these measures nearly a line and a half in width, whilst the largest tube present is four lines broad. If, therefore, there is this marked difference between the extremes of portions of what are to all intents and purposes the same species, it is just possible M'Coy's *S. membranaceus* may only represent an individual of still larger growth, notwithstanding that its width is six lines. The only difference between the latter and the form I am now referring to is the wrinkled integument, the latter being in the specimens quite smooth.[1] One strong point in the argument against the identity of *S. carbonarius* and *S. membranaceus* lies in the fact that at certain localities, for instance, Teases Quarry, near Lundin, Fife, the former occurs in quantity, but always the small form, and of one uniform size.

This question is one which can much more readily be settled by close examination in the field of large beds of these peculiar worm-tubes, and must for the present remain open.

Loc. and Horizon.—Messrs. Armstrong and Young[2] give several localities at which *S. membranaceus* occurs, viz. Gair Quarry, near Carluke, in the Upper Carboniferous Limestone Group; in the main limestone of the Lower Carboniferous Limestone Group at Carluke, etc.

[1] In specimens from other localities, however, the surface is quite as much wrinkled as in M'Coy's *S. membranaceus.*

[2] Trans. Geol. Soc. Glasgow, iii. App. p. 23.

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

IV.—On the Unconformability of the Keuper and Bunter.

By E. Wilson, F.G.S.

THE following instance of the unconformability of the Keuper and Bunter divisions of the Trias, which came under my notice during the construction of the Great Northern Derbyshire Extension line in the year 1877, is deserving of notice, not only from its decided rarity,[1] but also from its exceptional clearness.

In the railway tunnel cuttings at Morley, near Derby[2] (see Geol. Surv. Map, 71 N.W.), the Keuper, which consists of red marls with thin beds of sandstone below, and red marls above (apparently representing the lower portion of the Upper Keuper graduating down into the Lower Keuper), may be seen reposing on a well-levelled surface of the Bunter Pebble Beds.

On the east side, at the tunnel entrance, the Keuper dips a little north of west at an angle of 4° or 5°. The dip of the Bunter at this point (as defined by a band of marl which separates the Lower Mottled Sandstone from the Pebble Beds) is nearly due west at 7° or 8°. Going east, the westerly dip of the Keuper increases to from 6° to 8°, and that of the underlying Bunter to 10° or 12°. Coincidently with this difference in dip the Pebble Beds are visibly overlapped on the east in a space of three chains, to an extent represented by a diminution from thirty-eight to twenty-five feet—the total thickness of this subdivision of the Trias! The Pebble Beds are succeeded by the Lower Bunter, which consists of about a hundred feet of false-bedded sandstone with three broad bands of brecciated conglomerate in its lower portion. The Lower Mottled Sandstone, which, like the Pebble Beds, dips west, at from 12° to 14° or 15°, rests with a pronounced unconformity on the truncated edges of purple and light blue shales of the Lower Coal-measures that dip in a contrary (easterly) direction at an angle of 12°[3] (see Fig.).

At Morley village, half a mile north of the railway, Upper Keuper Marls may be seen in the road cuttings resting directly (and without an appreciable dip) on an eroded surface of the Lower Bunter Sandstone, which, with a brecciated base, reposes on deep red Coal-measure shales, similar to those exposed in the Morley tunnel cutting.[4] The Lower Bunter Sandstone must be here considerably reduced in thickness, for between the outcrop of the Coal-measures and of the Keuper there is not room for more than fifteen feet or so of that rock. The disappearance of the Bunter Pebble Beds, and

[1] Hull, Geology of the Country around Wigan, Mem. Geol. Surv. p. 31. Triassic and Permian Rocks, p. 87.

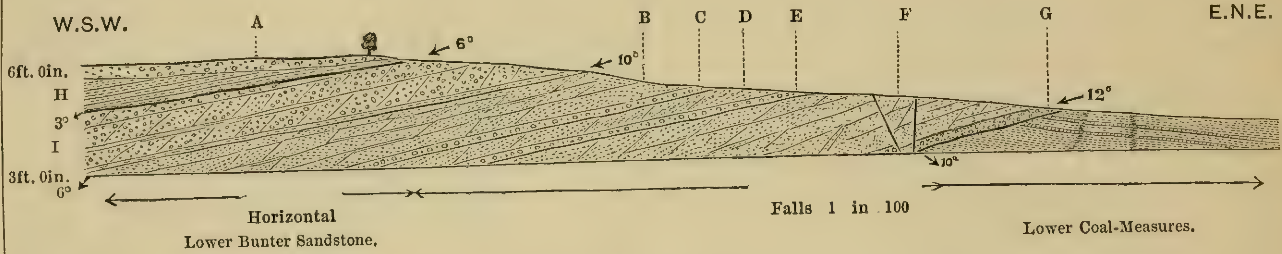
[2] This interesting section is within an hour's walk of either Breadsall or West Hallam Stations on the Great Northern Railway.

[3] The dips in the section do not correspond with those here given, because the section is not taken along the true line of dip.

[4] It was the fancied textural resemblance of these red rocks of the Lower Bunter Sandstone and Coal-measures to Rothliegende, which appears to have led the Government surveyors to club them together and map them as Permian Lower Red Sandstone. At Dale Mill a similar mistake was made with characteristic massively-bedded Coal-measure sandstone.

SECTION ON EAST SIDE OF TUNNEL AT MORLEY, NEAR DERBY.

(SHOWING UNCONFORMABILITY OF KEUPER AND BUNTER.)



The light-shaded left-hand portion of the diagram represents the Lower Bunter Sandstone, and the dark-shaded portion the Lower Coal-Measures (Ganister series).

A Boulder Clay.
B Sandstone, 33ft.
C Breccia, 4ft. 6in.
D Sandstone, 11ft. 6in.
E Breccia, 5ft.
F Sandstone, 42ft.
G Breccia, 7ft.
H Lower Keuper Sandstone, 20ft.
I Middle Bunter (Pebble beds), 33ft. to 25ft.

SCALES—Horizontal and Vertical—2 chains to 1 inch.

the cutting out of the lower beds of the Keuper shown in the railway cuttings, are certainly due to Keuper overlap. This also will account, in part at least, for the rapid attenuation of the Lower Mottled Sandstone.

The *lower* portion of the Lower Bunter Sandstone may, perhaps, be excluded by a rising of the old Carboniferous surface on the north (for we must not forget that we are here dealing with a double unconformability—one at the base of the Keuper, and the other at the bottom of the Bunter). If so, the breccias at Morley village may represent the upper breccias at Morley tunnel, with which, by the way, they appear to agree, both in textural characters and in consisting of a double band of breccia separated by mottled sandstone. In any case the Keuper Marls must very soon have overlapped the whole of the Bunter Series in a northerly direction, and come to rest directly on Carboniferous rocks.

Now, at Nottingham, ten miles east of Morley, Bunter Pebble Beds attain a thickness of over 200 feet, the Lower Keuper Sandstone (Waterstones) is about 100 feet thick, and beneath the latter is a fluctuating deposit of Keuper Basement Beds. The Lower Mottled Sandstone in the Morley tunnel cutting, where the Pebble Beds are so meagrely represented, is quite as thick, indeed somewhat thicker than it is at Nottingham, and the Middle and Lower Bunter Sandstone Series are clearly conformable to each other, whereas the dip of the Bunter is, as we have seen, appreciably greater than that of the Keuper. The above very decided overlap, then, is evidently due, not to contemporaneous attenuation, but to upheaval and denudation during the great interval of time which separated the close of the Bunter from the commencement of the Keuper epoch.

V.—The "Laterite" of the Indian Peninsula.

By W. J. McGee,
of Farley, Iowa, U.S.A.

THIS paper may be regarded as a notice of those portions of the recently published "Manual of the Geology of India," by Messrs. Medlicott and Blanford, which describe, or in any way relate to, the extensive lateritic deposits of Peninsular India. The hypothesis (or, more properly, the modification of an antecedent hypothesis) herein offered, in the hope that it may be tested by the Indian geologists, is based on extended examinations of deposits believed to be analogous, and has been found to satisfactorily explain the phenomena observed.

Description, etc.—Laterite is essentially a highly ferruginous clay. The iron is a peroxide, is irregularly disseminated, and often occurs in pisolitic nodules—more rarely in tortuous tubes or pipes of variable size. The rock often contains 25 to 35 per cent. or more of metallic iron; and it may contain sand or other detrital materials. It recements itself, when broken, into a mass closely resembling the original rock; and clays underlying it seem to be gradually converted into the same substance—the superimposed laterite merging into lithomarge, less ferruginous below, and finally into the clay formed by the decomposition of the subjacent rocks. Two varieties are recognized: high-level laterite, and low-level laterite; but the one merges into the other. The low-level variety is supposed to have been washed down from above and recemented; but in some cases in which it is interstratified with Eocene beds (as at Surat) it cannot be more modern than the high-level variety. It occurs in perfection on the Deccan plateau, where it sometimes reaches a thickness of 200 feet. Most commonly, but not invariably, it rests upon igneous rocks.

Laterite has, by different observers, been attributed to chemical change, *in sitû,* of the volcanic rocks on which it usually reposes; but this hypothesis does not fill all requirements. The hypothesis provisionally offered by the authors of the present "Manual" was partially suggested by the late Sir Charles Lyell. The deposit is supposed to consist of metamorphosed volcanic ashes, scoriæ, and tufas. The geological age of the high-level variety is hence (inferentially) supposed to be somewhat less than that of the Deccan traps (which were ejected about the close of the Cretaceous); but the low-level variety, which sometimes contains human relics, is believed to be later Tertiary or recent.

Difficulties of the hypothesis.—The above explanation is only offered as a "possible hypothesis," and its difficulties are stated with that candour, deference to the opinions of others, and evident fairness, which characterize the work throughout. Some of these difficulties seem almost if not quite fatal. Thus the laterite overlies and seems to merge into igneous, metamorphic, and sedimentary rocks alike, as well as unconsolidated alluvial deposits; and in some of these cases the exposures are at high levels and far from eruptive centres, as near Gwalior, and in Bundelkhand. Furthermore, there are in Abyssinia large tracts of similar rocks to those of the Deccan, which are without any trace of laterite. Moreover, the constituents of the rock must have been subjected to very different orographical conditions at different localities (at Guzerat and Cutch, for instance, where it is of sedimentary origin, and interstratified with early Tertiary deposits, as compared with the summit of the Sahyadri range), which would be inimical to their similar metamorphosis if they were so incoherent as volcanic ashes and scoriæ. Again, the present disposition of the laterite does not seem to be that which a friable deposit, subject to long-continued erosion before consolidation took place, would assume. Once more, pisolitic iron ore, apparently homologous with laterite, is found both in Mesozoic sedimentary strata, as in the Rajmahal (Upper Gondwana) group (where it caps carbonaceous shale) and in Post-Tertiary alluvium, as at Calcutta, and occasionally throughout Bengal and Behar. Finally, the hypothesis does not explain the pipes, or tubular masses.

Ferriferous Deposits of the Upper Mississippi Basin.—These deposits, it is true, seem insignificant when compared with the Indian laterite; but it is at least probable that they differ from that mineral not in kind, but only in degree of development; and they are such as to throw some light on their mode of origin. The deposits are as follows:—1. In alluvium and upper till. In fertile sloughs and rich alluvial bottoms the boulders and pebbles are often incrusted, and thin layers of sand and gravel are sometimes cemented, with ferric oxides. There are also in like situations, pisolitic nodules (compact throughout) of peroxide of iron irregularly disseminated, pipes of the same evidently formed around roots of grasses, etc., occasional thin bands of bog-ore, and ferruginous concretions (a crust of limonite without—ochreous and incoherent within), which may be found in any stage of formation. Rarely, as below rich pastures or barnyards, the upper till is impregnated with protoxide of iron. 2. Lower till. The whole formation is rich in iron, too generally disseminated to be of economical importance. It is coloured by the protoxide. It occasionally contains deposits of impure bog-ore, some feet in thickness, small masses of pyrites, etc., and cylindrical ferruginous concretions (distinct from both the above—evidently formed around roots), hollow or containing a woody core, and exhibiting the concentric structure of exogenous wood. The same horizon is highly carbonaceous, also, containing much wood, peat, lignite, ozokerite, etc. 3. Subjacent formations. Below the lower till a ferruginous deposit of local and erratic materials sometimes occurs. It may be either a lithomarge or a conglomerate of sand and northern pebbles in a matrix of earthy limonite. The products of the secular disintegration of the sedimentary strata are similarly ferruginous—much more so than the unaltered rock—and contain limonitic concretions. Within the cavities of the Palæozoic rocks considerable masses of iron are sometimes found, which resemble the smaller concretions of the upper till in structure and material, and probably also in origin and—approximately—in age.[1] These are not to be confounded with interstratified ore-bands.

Briefly, the Mississippi valley ores are attributed to the agency of decomposing vegetable matter in liberating the iron from adjacent rocks and earths, and the subsequent combination of this iron with the atmospheric oxygen. This property of vegetal solution was long ago pointed out by Dr. Sterry Hunt. Accordingly, the iron is most abundant in those formations and localities in which the decomposition of vegetable matter has been greatest.

Application of the hypothesis to the lateritic formations.—In accordance with the principle indicated above it may be suggested that the Indian laterite is the product of alteration *in sitû* of the underlying rocks by the usually recognized atmospheric and chemical agencies, modified by the action of decomposing vegetation. In consequence of the operation of this last factor, all the iron of the rocks has probably been retained near its original position (and possibly increased through metasomatism), while other elements have been borne off in the winds or carried down to the sea. The accumula-

[1] For more complete description, see papers by the author in Proc. Am. Assoc. Adv. Sci., 1878, and in Geol. Mag. for August and September, 1879, as well as the different State Reports.

tion of laterite in any region would, if this view be correct, depend; (1) on the solubility of the basal rock; (2) on the proportion of contained iron; (3) on the fertility of the soil formed by its disintegration; and (4)—very largely—on the climate of the region.

In view of the unrivalled opportunities of the Indian geologists for testing not only the value of this suggestion, but the validity of that recognized principle in the genesis of iron ores on which it is based, it will be needless to discuss the applicability of the hypothesis at length. Suffice it to remind extra-Indian geologists that at least those of the above-named conditions were decidedly favourable to the formation of the laterite. 1. The dolerites and other rocks do not seem to be unusually soluble, though sufficiently so for the requirements of the hypothesis. 2. The proportion of iron in the whole series of Indian rocks is very large—astonishingly so, to an American geologist. The general association of carbonaceous and ferruginous deposits throughout the series is quite remarkable, and, of course, makes for the hypothesis. 3. The disintegrated rocks, notably the traps, form a soil of marked fertility; and abundant plant-remains attest equal fertility during Mesozoic and Tertiary ages. The comparative poverty of the existing flora is largely due to annual burnings, and to the porosity of the lateritic soil; but even in recent times pisolitic nodules of iron have accumulated abundantly in the alluvium of Bengal and Behar beneath the jungles of the Ganges and the Hoogly. 4. The climate to-day fosters luxuriant vegetal development, and it must have been still more auspicious during the mild seasons of the early Tertiary. There is evidence in the recent accumulation of *reh*, as well as in the distribution of existing organisms, that in late geological times India enjoyed a moister climate than that of to-day—precisely such a climate, in fact, as would follow the clothing of plateau and valley with such a mantle of vegetation as to-day exists in the Madupur jungle. The roots and perhaps sometimes the trunks of the forest trees of that epoch seem to have left their impress in the ferruginous soil, just as their homologues in the Mississippi valley are preserved in the lower till.

VI.—On the Distribution and Identification of the Palæozoic Rocks of the Northern Punjab.

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

SPECULATION having been rather freely applied to the identification of these rocks, I beg to offer a few notes upon the subject, the facts regarding which I have described in a paper already published.[1]

It will be as well at first to indicate briefly where the rocks referred to are situated.

On the map accompanying the Indian Geological Survey Manual, the Carboniferous and Silurian formations are shown to be largely developed in the Himalayas, the former prominently in the interior

[1] Records Geol. Surv. Ind. vol. xii. part 2, and Map.

of this mountainous region. Both reappear in Kashmír, and it is on record that supposed Silurian fossils have been found in the country towards the Khyber Pass, in the direction of Afghanistán. Carboniferous fossils have also been recorded as occurring in the boulders of the Kurram and other rivers flowing from that country into the Punjab. Hence it would appear likely that the mountains of the Safed Koh range and northern part of the Súlíman chain contain recognizable representatives of these old formations.

As if linking these western rocks with the Himalayan Palæozoic regions, there is the well-known large Carboniferous exposure of the West Salt Range; while beds referred by competent palæontological authority to the Silurian are found in eastern parts of the same range. This range itself subtends the angular embayment of the Upper Punjab plateaux among the lofty mountains supporting the higher regions of Central and Western Asia.

But northwards from the Salt Range no representatives of the Carboniferous or Silurian rocks have hitherto been satisfactorily or definitely recognized among the frontier hills, either by palæontological or lithological evidence. There are two or three unfossiliferous groups in this region supposed to be of Palæozoic age; amongst these, if Carboniferous and Silurian representatives are present, the fact as yet can only be guessed.

It should be noticed that the occurrence of Silurian rocks in Kashmír is assumed only, rather than proved by local fossil evidence, and that the facts as to the existence of beds with Silurian fossils about the Khyber mountains (eastern end of the Safed Koh) are very hazy now; they seem, however, to have been better known to Indian geologists, unfortunately no longer living.

The Carboniferous rocks of Kashmír were supposed by Lydekker to have been deposited in isolated areas, as if the deposits of the period were limited laterally, and this formation has been found only in the Western Salt Range sections. These facts as to partial distribution have an important bearing upon the identification of Silurian and Carboniferous groups in the northern frontier regions of the Punjab.

The structural features of the most accessible portion of the last-named region, in the district of Hazara, point to the arrangement of the rocks in the following order. It appears paradoxical, but until explained in some rational way there is no reason that I know of to question the accuracy of observations showing the succession as here presented, the most highly metamorphosed rocks uppermost:—

Metamorphic.	4. Gneiss, Quartzite, Schist, Traps.	
,, ,,	3. Schists, Traps.	
Tanôl group.	2. Quartzites, Slates, Dolomites, &c.	Infra-Trias.
UNCONFORMITY.		
Attock Slates.	1. Slates of various colours, fine grits.	Limestones, Dolomites, &c.

Southwards of a certain line the succession differs, No. 2 is absent or barely represented, or replaced by thick siliceous dolomites of no great lateral range, overlaid by Trias-Jura limestones, Jurassic shales, a meagre Cretaceous representative in places, and the whole surmounted by Nummulitic limestones and later Tertiary sandstones and clays.

The black slate group, No. 1, apparently occupying the lowest stratigraphical position; from its extension westwards towards the Khyber route to Kabul, had long been supposed to be the formation in which the Silurian fossils had been found by Falconer and Vicary, but what these fossils really were has become doubtful, and it is uncertain from which group they came. Recently, however, Dr. Waagen has obtained from the Geological Society of London some specimens of a Carboniferous *Spirifer* (*Spirifer Rajah*, Salter) in a black slate which he considers identical with similar rock in the Attock slates.[1]

The conclusion from this, that the Attock slates are of Carboniferous age, is unfortunately of little more value (if any) than the conjecture that they are Silurian. The fossils were only labelled 'Punjab,' and if Punjab labelling were to be relied upon, these Attock slates ought to have been Tertiary; an old collection of somewhat pre-Siwalik forms, which never came from Attock, having long borne the name of the "Attock fossils." Besides this there are several rock groups in the Punjab which contain dark or even black slaty beds as well as the Attock slates; they can be found in the Salt Range Carboniferous, and in the Tanôls, quite indistinguishable from some of the Attock slate; as well as in the newer formations, while slaty cleavage may be present or absent, accidentally, in any of the older groups of the country.

Even supposing some of the earlier trans-frontier collections had been re-discovered, and that the fossils came from these slates near the Khyber Pass (*Spirifer* being among those mentioned by Vicary), much more evidence than that given by a single species would be required, and it should be shown that the occurrence of *Spirifer Rajah* anywhere except in the Carboniferous is an impossibility. Dr. Waagen having found *Ammonites* in the Punjab Carboniferous, it would become desirable to receive with considerable doubt the evidence of one Carboniferous species, in a rock labelled 'Punjab,' even though petrographically similar to part of a great formation marked by considerable variation amongst its beds.

I have searched these Attock slates so extensively for fossils without success that I am rather incredulous as to their containing, at least in the Punjab, any except microscopic organisms: in some of the limestone bands belonging to or associated with them I have found faint traces of fossils, but never any in the slates nor any that presented a hope of recognition anywhere. There are slaty rocks in the Carboniferous groups of Kashmír, and in those at Eishmakam I found Bryozoa and Trilobites; but the rocks differ considerably in aspect from any part of the Attock slates with which I am acquainted.

The attempt has been made to draw a parallel between the strong, dark, frilled and altered limestones, interstratified with the Attock slates of the Gandgarh range (Hazara), and those called the 'great

[1] Records Geol. Surv. Ind. vol. xii. pt. 4.

limestones' supposed to be of Carboniferous age in the Jamú hills. I have not seen these latter rocks in the Jamú country; so that I could never have suggested they resembled the Gandgarh rocks, as I am represented to have done.[1]

On the whole, it may be stated that the true age of the Attock slates is quite uncertain. From their position, the presumption would be that they are among the oldest rocks of the northern Punjab, and thus more likely perhaps to be Silurian or Cambrian than Carboniferous. Any other surmise is at present unsafe and unwarranted.

The next group, the Tanôls and their related Infra-Triassic cherty dolomites, etc., neither of them, afford any palæontological evidence as to age. Though the cherty dolomites of one region (Sirban) have been separated from the Trias above, because there was no proof that they belonged to that formation, it is equally true there is no proof that they do not. Appearances point to the greater or less identity of the Tanôl group, or some part of it, with the Infra-Trias dolomites, etc., or to the latter being merely a local form of the Tanôls,—it may be, attendant upon the disappearance of the whole group southwards. The Tanôl beds might with some apparent probability be assigned to the Carboniferous age, but it would be a mere guess. The group does not seem from description to resemble closely any of the neighbouring Kashmír subdivisions; yet isolated areas of deposition once admitted, it might be correlated with any group older than Trias or with the lowest part of that formation.

It is true the dolomites of one locality, or the quartzites of another, with or without slaty beds resembling Attock slates, are more prominent according to geographical place, and if laterally interrupted deposition took place, there would be no reason for supposing the Infra-Trias and Tanôls formed two groups instead of one, while in the absence of fossils it would be useless presumption to call the rocks of either Silurian.

The physical relation of these Tanôl rocks to the more highly altered superincumbent schists, gneiss, etc., is no new feature in Himalayan geology, and is one scarcely to be disposed of by hasty suggestions of inversion and faulting, unsupported by any analysis or synthesis of the method by which the local results were produced. In the present case these assumptions seem to be impossible on the hypothesis that the Tanôls and Infra-Trias form parts of one group resting unconformably upon the slates. And even setting this aside, it must be shown, in order to support the suggestion, how an anticlinal dome can be turned completely inside out, presenting a series of bedded rocks 'overthrown' so as to dip radially towards a central area for 30 miles across the strike, the really oldest beds forming the internal and uppermost strata of a basin.

It is thought that the whole chain of the Pír Panjál between Kashmír and the Punjab forms a great anticlinal arch pushed over towards the plains so as to give inverted dips on the outer flank (Lydekker). In this case the inverted part of the section is disposed

[1] Records. Geol. Surv. India, vol. xii. pt. 4, p. 184, foot.

more or less in a straight line of strike, and its distance across at right angles to the bedding is perhaps scarcely a quarter of that occupied by parts of the so-called inversion of the Tanôl and metamorphic rocks of the Northern Punjab. The dip angles in these last, too, are greatly lower than those along the Pír Panjál.

Except for the uppermost beds being the most metamorphosed, it may be doubted whether any one would feel compelled to invoke the aid of an inexplicable inversion in order to contradict very ordinary and self-evident structural facts. That inversion is frequently present in disturbed districts, no field-geologist would deny; but where its presence is unnecessary to explain the facts, this need not be asserted on insufficient evidence, nor does there seem to be any conclusive reason why metamorphism need always, or only be assumed to have acted vertically upwards.

If the relative position of the rocks could have been explained by simple inversion, and if the unconformity at the base of the Tanôl-Infra-Trias group, which could not have escaped participation in the overthrow, had no existence; it would have been a very simple matter to assign conjectural places to each of the groups older than the fossil-bearing Trias. Geological difficulties are not to be solved, however, by losing sight of the conditions presented to observation.

The riddles of the northern Punjab may be doubtless read when ample time and patient labour have been devoted to recording each geological feature upon large-scale maps and in carefully made sections; till this can be done, it will be wiser to put forward the mere speculations of cabinet geology accompanied by ample reservations, and to refrain from accepting theories as facts.

NOTICES OF MEMOIRS.

Radiolaria in "diaspro."—Bolletino del R. Comitato d'Italia, 1880. Nos. 1, 2.

THE above Journal contains a report of a verbal announcement made by Prof. Dante Pantanelli, on the discovery of *Radiolaria* in the Italian "Diaspro" from various places, and of different ages; two from the Lias, and one probably Cretaceous, but the greater number were from the Upper Eocene. In a previous meeting of the same Society (Soc. Toscana di Sc. Nat.), Prof. de Stefani, in speaking of this diaspro and manganite, attributed their formation to deposits in deep seas, but this idea was combated, and in consequence, Prof. Pantanelli undertook the examination, with the above results. The importance of this is much increased by the fact, that the diaspro of Murlo and Crevole are intercalated with the serpentine, and we may hope that much light will thus be definitely thrown on a question which is occupying much attention in Italy, and has also been taken up by some of our leading English geologists, we mean the formation of the Italian serpentines. Prof. Pantanelli thinks we may now definitely accept the hypothesis of Stoppani that the serpentines are volcanic rocks, for the most part erupted in deep seas. Thus the same conclusion is arrived at from quite different stand-points. He also thinks it may facilitate an explanation of the mode of formation of manganese deposits, as they occur in connexion with the diaspro rich in fossils, and hints, that it would make us doubt the possibility of their being formed by an endogenous action, or from deposits of mineral water.

Prof. de Stefani called attention to the use the microscope may now be to the anthropologists, in showing from what locality implements made of this rock were derived.

The writer of this notice believes he is in a position to refer to the Eocene "diaspro" the rock mentioned by Prof. Bonney in this Magazine last year (August, No. 182, p. 369), in which attention was called to its containing fossils, which Prof. Bonney was himself inclined to refer to Radiolaria and Bryozoa, and can also add that Professor Pantanelli has in the press an article describing a large number of the Radiolaria observed. A. W. W.

REVIEWS.

I.—On the Structure and Affinities of the Platysomidæ. By Ramsay H. Traquair, M.D. Transactions of the Royal Society of Edinburgh, vol. xxix. pp. 343-391, Pls. iii.-vi.

In the above memoir Dr. Traquair discusses an interesting group of deep-bodied Palæozoic fishes, some forms of which have long perplexed Palæichthyologists as regards their affinities and systematic position among the Ganoids. The position and form of the teeth, the skeletal structure, conformation and attachment of the scales; the absence, presence, or form of certain fins, having been the objects respectively studied, has led, as a natural consequence, to the publication of many and diverse opinions in regard to these characters, and their bearing upon the classification. Yet none of the respective authors have hitherto succeeded in establishing the natural position of the group in the above order of fishes upon a basis sufficiently satisfactory to be permanently, or even generally accepted; nor has their relationship to the many, and in some instances widely separated genera, with which they have been associated by one author or the other.

In a concise but comprehensive introduction, which commences with an enumeration of the genera Dr. Traquair refers to the family *Platysomidæ* as enlarged by himself (viz. *Eurynotus*, Ag.; *Benedenius*, Traq.; *Mesolepis*, Young; *Eurysomus*, Young; *Wardichthys*, Traq.; *Cheirodus*, M'Coy (*Amphicentrum*, Young); *Platysomus*, Ag.), is embodied the various views enunciated respecting the structure and classification of some of these genera, of which the following is a brief résumé. Agassiz classed *Eurynotus* and *Platysomus* (including *Eurysomus*) in his Lepidoid family of Ganoids. Giebel includes the same genera in his "Heterocerci Monopterygii," along with Palæoniscoid genera, and also with *Eugnathus*, *Conodus*, and *Megalichthys*. Quenstedt places *Platysomus* among the Heterocercal Ganoids, immediately after *Palæoniscus*, *Amblypterus*, and *Pygopterus*. Sir Philip Egerton advocated the removal of *Platysomus* to the Pycnodontidæ, on account of the form and arrangement of the teeth which had been discovered in a mandible of *Platysomus macrurus*, and also upon the conformation and articulation of the scales. This classification was approved by Agassiz, and was favourably received by other authors; Geinitz, Pictet, and M'Coy, in their respective systematic works having included the genus in the same family. However, Vogt, Heckel, Wagner, and Prof. John Young declined to accept this assignment of *Platysomus*. Vogt still associating *Platysomus* and also *Eurynotus* with the Palæonisci. Wagner includes *Platysomus*, *Dapedius*, *Tetragonolepis*, and his two new genera, *Homœlepis* and *Heterostrophus*, and also *Pleurolepis*, Quenst., in a new family "Stylodontes" which he proposed for their reception; regarding which, Dr. Traquair remarks, "That the association by Wagner of *Platysomus* with those other genera is just as unnatural as the classification which he himself wrote to oppose."

Subsequently, Prof. J. Young, who had specially studied *Platysomus* and some kindred fishes from the Coal-measures, and upon which forms he established the genera *Amphicentrum* and *Mesolepis*, "declined to accept the peculiar dentition of *Platysomus macrurus* as characteristic of all the species which had been referred to that genus;" he therefore assigns it to a new genus, *Eurysomus*, and makes *Platysomus parvulus*, Ag. (a Coal-measure species), the type of the genus *Platysomus*; and states that each of the above genera are distinct from, although possessing affinities to, the Pycnodontidæ. He therefore, having reference to the mode of the articulation of the scales, proposed a new suborder "Lepidopleuridæ," containing five families, which are mainly founded upon the dentition, and subdivided into two divisions, respectively characterized by the absence or presence of the ventral fins. The first division, in which the ventral fin is wanting, includes the families PLATYSOMIDÆ, AMPHICENTRIDÆ, and EURYSOMIDÆ; the second, where the fins are present, contains MESOLEPIDÆ and PYCNODONTIDÆ. These views of Prof. Young, as regards the institution of the suborder "Lepidopleuridæ," were also favourably received, among others by Dr. Lütken and Professor Victor Carus, but exceptions were taken to some details of arrangement and classification of the genera composing it. More recently Prof. E. D. Cope, apparently unaware of Prof. Young's investigations, places *Platysomus* with *Dapedius* and *Tetragonolepis* in one family, which he terms "*Dapediidæ*," excluding *Eurynotus*, which he places along with *Lepidotus*, and *Pholidophorus*, in the family Lepidotidæ.

The preceding summary indicates the interest attached to some members of this family of ancient fishes by previous investigators, and also the difficulty experienced in providing them with a satisfactory scientific location and with congenial alliances. Our author concludes his introduction by confidently asserting "that the Palæozoic forms enumerated on the first page of this memoir constitute a connected series is undeniable, and, considering the small number of genera, it seems convenient to follow Dr. Lütken and Prof. Carus in uniting them in one family group." And further, he adds, "that these fishes have little in common with the Pycnodonts, while they are intimately allied to the Palæoniscidæ, and that the suborder 'Lepidopleuridæ' must be abandoned,—to follow up this idea more in detail is the object of the present paper. I shall, therefore, first review the structural features of the Platysomidæ, genus by genus, and from the facts thus acquired, endeavour, in conclusion, to justify my views as to their real position, and as to the validity, or not, of the suborder established by Prof. Young."

Then follow interesting details relating to the "History," "Geological Distribution," and "Structure," of each genus, including notes or descriptions of the species appertaining to each. The structural descriptions are founded mainly upon original examination and study of specimens not available to the earlier students, and notably upon many examples in the celebrated collection of Coal-measure fishes belonging to Mr. Ward, of Longton.

The author's extensive and well-known knowledge—practical and theoretical—of the dental, and the external and internal skeletal structure of fishes, renders this portion of the memoir of exceeding value; inasmuch, as the gradations in form and character of special parts, namely, the dentition, bones of the head, and scales, denoting the degree, and also the order, in which the respective genera approach or diverge each from the other, with the variations in external form consequent thereon, are fully considered and discussed. And although this descriptive portion is necessarily technical, it is presented to the reader in his usual clear and intelligible manner. Our space will not permit of long quotations, and abbreviation is hardly practicable; to be understood the descriptive details must be read in connexion with the excellent figures which illustrate the text.

The new species described are only two, namely, *Mesolepis micropterus*, Tr., and *Platysomus tenuistriatus*, Tr.; both from the Lower Coal-measures of Derbyshire. On the other hand, *P. declivus*, Ag., is erased from our lists of British fossils, the species having been founded upon a distorted specimen of *Eurynotus;* and to this genus is also referred the *P.* ? *insignis* of De Koninck, from the Belgian Carboniferous Limestone.

The reasons for allying the Platysomidæ with the Palæoniscidæ, and not with the deep-bodied fishes constituting the families Dapediidæ and Pycnodontidæ; together with the details of the special points of differences in the anatomical structure of the fishes of each group upon which he bases his conclusions regarding their affinities, are succinctly, and we think we may safely add, convincingly stated. The structural points in which the Platysomidæ resemble the Dapediidæ and Pycnodontidæ being few, and the differences many and important. Whilst the anatomical characters which assimilate the group to the Palæoniscidæ are numerous; nevertheless, he admits that the points of difference are also many and striking, but "are quite insufficient to conceal the close affinity between them": and regarding which our author observes, that "weighing these points of resemblance and difference together, it is quite obvious that the latter are of a much more superficial nature than the former; in other words, the Platysomid type is simply a modification of the

Palæoniscid one. The Platysomidæ are *specialised Palæoniscidæ.*" And from these facts, founded upon minute study and comparison, he thinks he is justified in concluding:—

"1. That the Platysomidæ are specialised forms, which have, if the doctrine of descent be true, been derived from the Palæoniscidæ. Their structure presents us simply with a modification of the Palæoniscid type, and wherever the Palæoniscidæ are placed in the system, thither the Platysomidæ must follow.

"2. The resemblances between the Platysomidæ and the Dapediidæ and Pycnodontidæ are mere resemblances of analogy, and not of real affinity. The Dapediidæ are related not to the Palæoniscidæ or Platysomidæ, but to the other semiheterocercal Ganoids of the Jurassic era (*Lepidotus*, etc.), and the Pycnodonts are highly specialised forms, whose general affinities point in the same direction."

This memoir is a valuable instalment to the series of papers previously published by the author relating to the history and classification of the fishes of the Coal-measure and other Palæozoic deposits; a subject upon which he has long been occupied. It is illustrated with four excellent plates, containing upwards of 60 figures, drawn chiefly by himself, which is a guarantee for their accuracy.

II.—L'Origine des Inégalites de la Surface du Globe. By A. de Lapparent. Revue des Questions scientifiques, July, 1879.

As people get old, their clothes sometimes become too large for them; and so it seems to be with the earth, whose surface behaves like a cloth forced into wrinkles by the diminution in volume of its support due to secular cooling.

In the application of this principle lies the clue both to the existing orography of the globe, and also to many of the phenomena of geology, as is ably argued within the compass of twenty-four tersely written pages.

The terrestrial surface bears throughout the mark of a lateral thrust, which has found in the mountains its supreme expression. These represent the salient portion of the wrinkles, and thus the idea of upheaval has a certain justification—none the less, because these local upheavals are the result of a general sinking of the crust.

The author is desirous to disconnect Elie de Beaumont with Von Buch's "crater of elevation" theory. Far otherwise is the real structure of mountain chains, which are often composed of stratified rocks, either with or without a crystalline nucleus, than of volcanic cones, and it usually happens that the crest does not occupy a central position with two symmetrical slopes, but the chain is unsymmetrical, having its steepest side towards the sea. This rule may not be true of all chains as they at present exist, but we must remember that they are of different geologic ages, and that each was accentuated at a certain epoch, which should be deemed its age. The normal, however, is an oceanic depression sloping gently towards its line of greatest depth, from which at a high angle spring the submerged and emerged portions of the coast chain, to slope away at a gentle angle, and gradually fade into the continental "massif." M. de Lapparent is a thorough believer in the fluidity of the interior nucleus, and maintains that the weakness inherent in the steep side of the chain affords an opportunity for the escape of the fluid matter as volcanic ejectamenta. Perhaps, after all, it is not easy to conceive a theory which shall meet every case, and some might be disposed to think that the author takes too little notice of such immense accumulations of ejected matter unconnected with any definite chain, such as may be seen on a large scale in Iceland and in America. No doubt he claims that the roots of his volcanos shall be near water, but he says nothing of the important part which steam must play, both chemically and dynamically, as an agent in effecting extravasations on the surface. W. H. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 12, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Structure and Affinities of the Genus *Protospongia*, Salter." By W. J. Sollas, Esq., M.A., F.G.S.

In this paper the author described the character of the Cambrian genus *Protospongia* from the original and other specimens. In Dr. Hicks's specimen the spicules of the sponge show their original form, when it is clear that they are not fused together into a continuous network; they form a network only by the interlacing of their extremities. The spicules are quadriradiate, with the centre raised, so that each spicule indicates the outlines of a low four-sided pyramid, the centre being at the apex, and the four rays representing the four edges of the pyramid. The rays do not diverge at right angles, and thus the base of the pyramid is oblong, though this may be due to distortion. From some indications the author is inclined to believe that a fifth ray may have sprung from the centre of the spicule downwards. The rays of the spicules appear to be cylindrical. The spicules are generally of several sizes, the larger ones forming a framework which is filled in by the smaller forms, the latter being regularly arranged, so that the smaller ones fill up the square spaces left between the rays of the larger, and thus build up a network of square meshes gradually diminishing in size. The sponge-wall seems to have consisted of more than one layer of spicules. The spicules were probably originally siliceous, but now they consist of iron pyrites.

With regard to the systematic position of *Protospongia*, the oldest known sponge, the author remarks that similar spicules similarly arranged are to be met with in the Hexactinellidæ, the absence of one or two rays being not unusual in part of the spicules of true Hexactinellids. As the spicules are free, he would refer the sponge to Zittel's Lyssakina, which are nearly equivalent to Carter's Sarcohexactinellida.

2. "Note on *Psephophorus polygonus*, von Meyer, a new Type of Chelonian Reptile allied to the Leathery Turtles." By Prof. H. G. Seeley, F.R.S., F.G.S.

The specimen described is a portion of the shield from the anterior dorsal region, and was obtained from the later Tertiary deposits of the borders of Croatia. It was originally regarded by Von Meyer as the armour of an Edentate mammal, but it was afterwards suggested by him and Prof. Fuchs that *Sphargis* presented a nearer affinity. A keel runs along the middle of the specimen, and is regarded by the author as one of the outer folds of the shield. The dermal skeleton is made up of irregularly polygonal plates of various sizes, closely resembling those of *Sphargis*, except that each plate is almost twice as large as those of that form. The plates usually show a radiate ornament on the surface. On the underside of the slab are the remains of several vertebræ, apparently from the base of the neck, and these differ from the vertebræ of all known Chelonians in having strong transverse processes for the attachment of ribs. The neural arch, like the processes, is anchylosed to the centrum. The author considers that the dermal skeleton is not represented in the carapace of ordinary Chelonia, but is represented by the granulations on the surface of the carapace of the Trionychidæ. He is hence led to indicate three primary divisions of the Chelonian order—viz. 1. *Aspidochelyidæ*, in which the bony carapace is covered with symmetrical horny scutes, including Turtles, Emydians and Tortoises; 2. *Peltochelyidæ*, in which the bony carapace has a granular surface-structure, and is covered with an undivided dermis without scutes, including only the Trionychidæ; and 3. The *Dermatochelyidæ*, in which the carapace is not developed, but is functionally represented by a bony skeleton within the skin, as in *Sphargis* and *Psephophorus*.

3. "On the Occurrence of the Glutton (*Gulo luscus*, Linn.) in the Forest Bed of Norfolk." By E. T. Newton, Esq., F.G.S.

Remains of the Glutton have hitherto been obtained only from cave-deposits. The author has lately received from Mr. R. Fitch, of Norwich, a portion of the lower jaw of this animal obtained from the Forest-bed of Mundesley, Norfolk. The specimen consists of about two inches of the left ramus, bearing the first true molar and the hinder half of the fourth premolar in place. The jaw is smaller than in average specimens of the recent Glutton, but presents all the characters of the species as described in detail by the author.

4. "A Review of the Family Diastoporidæ, for the Purpose of Classification." By George Robert Vine, Esq. Communicated by Prof. Duncan, F.R.S., F.G.S.

This family of the Cyclostomatous Polyzoa, never very prolific, has representatives from the Lower Silurian era to the present time, and is now northern and of deep-sea habit. The author discusses the limits of the family, and gives a list of the recent and fossil genera and species included in it. He points out that there are important differences in the Palæozoic forms, several of which, though he leaves them provisionally among the Diastoporidæ, he considers, on fuller examination, will have to be removed. The author describes the characteristics of some Palæozoic genera of true Diastoporidæ.

5. "On Annelid Jaws from the Wenlock and Ludlow Formations of the West of England." By G. J. Hinde, Esq., F.G.S.

Referring to his paper on annelid jaws from the Palæozoic rocks of

Canada and Scotland (Quart. Journ. Geol. Soc. vol. xxxv. p. 370), the author in this paper announced the discovery of similar objects in the Silurian deposits of Dudley, Much Wenlock, Iron Bridge, Stoke Edith, and near Ludlow. He noticed from these Silurian rocks seven species of *Eunicites*, two of which, *E. curtus* and *E. unguiculus* from the Wenlock, are new; nine species of *Œnonites*, of which six, namely, *Œ. regularis*, *naviformis*, *præacutus*, and *tubulatus* from the Wenlock, *Œ. insignificans* from the Upper Ludlow, and *Œ. aspersans* from the Wenlock, and Upper Ludlow, are described as new; seven species of *Arabellites*, four of which are new, namely, *A. extensus*, *spicatus*, and *obtusus* from the Wenlock, and *A. anglicus* from the Wenlock and Upper Ludlow; further, *Lumbriconereites basalis*, *Staurocephalites semula*, sp.n., and *Nereidavus antiquus*, sp.n., from the Wenlock group. Including varieties, 27 forms are noticed by the author, of which 21 are peculiar to the Wenlock group and 2 to the Ludlow, while 4 are common to the two groups. In the Wenlock there are 8 forms already described from American rocks, 3 occurring in the Cincinnati group, 3 in the Clinton, and 2 in both groups of rocks. Of the Ludlow forms, 2 occur in the Cincinnati group, and 1 of these also in the Clinton.

II.—May 26, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "The Pre-Carboniferous Rocks of Charnwood Forest." (Part III. Conclusion.) By Rev. E. Hill, M.A., F.G.S., and Prof. T. G. Bonney, M.A., F.R.S., F.G.S.

In their former communications the authors had paid less attention (from want of time) to the northern part of the forest than to the rest. This district has during the last two years engaged their special attention. They had provisionally retained the name quartzite for the rocks exposed about Blackbrook, etc., probably the lowest visible on the forest. This name proves to be inappropriate, and they propose to call the group, which contains much fine detrital volcanic material, the Blackbrook Series. They have also reason to believe that the anticlinal fault is less than was supposed, and that we have here a fairly unbroken base for the forest rock already described. In this case there ought to be representatives of the great agglomeratic masses on the western side of the anticlinal (High Towers, etc.). The authors believe that they have found these, though as much finer and more waterworn detritus, in the greenish grits above Longcliff and Buckhill. The authors also believe that they have succeeded in tracing a coarse agglomerate with slate fragments round about three-fourths of the circumference of the forest. Further notes upon the district of Bardon Hill, Peldar Tor, and Sharpley are given, and the origin of the remarkable rock of the last, so like some of the Ardennes porphyroids, is discussed; the authors believe it to be a volcanic tuff, altered by the passage of water or of acid gases. Descriptions of the microscopic structure of some of the rock fragments included in the coarse agglomerate and of some of the slates are given. Also a notice of two small outbursts of igneous rock, of the northern syenite type, previously unnoticed, are mentioned.

2. "On the Geological Age of Central and West Cornwall." By J. H. Collins, Esq., F.G.S.

The author divided the stratified rocks of this district into four groups, as follows:—

1. *The Fowey Beds*, mostly soft shales or fissile sandstones, with some beds of roofing slate; no limestones or conglomerates. These beds cover an area of not less than eighty square miles, and contain numerous fragmentary fish-remains and other fossils, many as yet undetermined, the whole, however, indicating that the beds are either Lower Devonian or Upper Silurian. The strike of the beds is N.W. to S.E., and they are estimated to be not less than 10,000 feet thick.

2. *The Ladock Beds*, consisting of slaty beds, sandy shales, sandstones, and conglomerates; no limestones and no fossils. They cover an area of more than 100 square miles to the west and south of St. Austell, strike from east to west, and overlie Lower Silurian rocks unconformably. They are estimated at from 1000 to 2000 feet thick.

3. *The Lower Silurians* consist largely of slates and shales, with some very thick conglomerates (one being at least 2000 feet thick), some quartzites, and a few thin beds of black limestone. The quartzites and limestones have yielded fossils (chiefly Orthidæ) which are pronounced to be of Bala or Caradoc age by Davidson and others. The total thickness of these beds is estimated at 23,000 feet, and the fossils are found in the upper beds only. Instead of occupying only about 12 square miles, as shown on the Survey Maps, they extend over nearly 200 square miles, and reach southward beyond the Helford River, and westward to Marazion. The strike of these rocks is from north-east to south-west.

4. *The Ponsanooth beds* occur beneath the Lower Silurians, and unconformable with them (strike north-west to south-east); they are often crystalline, and are estimated at 10,000 feet thick.

Each of these formations has its own set of intrusive rocks; each has been contorted and in part denuded away before the deposition of its successor.

The various granitic bosses have been pushed through this already complex mass of stratified rocks without materially altering their strike, which does not in general coincide with the line of junction.

The chemical effects of the igneous intrusions are generally considerable, and somewhat proportioned to their relative bulk.

3. "On a Second Precambrian Group in the Malvern Hills." By C. Callaway, Esq., D.Sc., F.G.S.

These rocks occupy an area of about half a square mile on the east of the Herefordshire Beacon; they are compact, flinty "hornstones," very like some of the rocks at Lilleshall, in Shropshire, which belong to the newer Precambrian group of the Wrekin. The strike is not distinct, but probably is quite discordant from that of the subjacent gneissic rocks. As in Shropshire, so here, Hollybush sandstone and *Dictyonema*-shales occur on the flank of the Precambrian mass, and each seems to have formed an island in the Lower Silurian seas, which, during the formation of the May-Hill group, was depressed. In fact, in both regions the chief movements of upheaval, subsidence and dislocation appear to have been contemporaneous. Thus they are very probably of the same age, and this probably is that of the Pebidians of St. Davids, to some of which they have, lithologically, a very close resemblance.

III.—June 9, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Occurrence of Marine Shells of Existing Species at Different Heights above the Present Level of the Sea." By J. Gwyn Jeffreys, LL.D., F.R.S., Treas. G.S.

This paper resulted from the author's examination of the Mollusca procured during the expeditions of H.M. SS. 'Lightning' and 'Porcupine' in the North Atlantic. He stated that he found several species of shells living only at depths of not less than between 9000 and 10,000 feet, which species occurred in a fossil state in Calabria and Sicily at heights of more than 2000 feet, such depths and heights together exceeding the height of Mount Etna above the present level of the Mediterranean. He then gave an account of the Post-Tertiary deposits in Europe, Asia, and North America, to show their various heights, and especially of the raised beach on Moel Tryfaen in Caernarvonshire, which was from 1170 to 1350 feet high. Some of the shells in that deposit were boreal and did not now live in the adjacent sea. The author stated that no shells of a peculiarly northern character had been noticed in the west or south of England. He then questioned the permanence and even the antiquity of the present oceanic basins, from a consideration not only of the fauna which now inhabits the greatest depths, but also of the extent of oscillation which had prevailed everywhere since the Tertiary period. A complete list of the Moel-Tryfaen fossils was given, to the number of 60, besides 3 distinct varieties, of which number 11 were arctic or northern, and the rest lived in Caernarvon Bay. All of these fossils were more or less fragmentary.

2. "On the Pre-Devonian Rocks of Bohemia." By J. E. Marr, Esq., B.A., F.G.S.

The author commenced with a brief notice of the Pre-Cambrian rocks, which are gneisses and schistose limestone with intrusive eclogite; over these lie unconformably green grits, ashes, breccias, hornstones (étage A of Barrande), which the author considers to represent the Harlech Group of Wales. Étage B is unconformable with this, but conformable with C, which contains the "primordial" fauna. D contains the colonies. E to H are Silurian, and more calcareous than those underlying them. The base of the group is unconformable with those beneath. The lithological characters of the various beds were described. The following are the associated igneous rocks:—Granite, Quartz-felsite, Porphyrite, Mica-trap, Diabase, Diorite, Eclogite. Of these brief descriptions were given. The author gave a comparison of the various shales with English deposits. The Pre-Cambrian Series much resemble the Dimetian and Pebidian of Wales, the latter being étage A; étage B, the Harlech; étage C, the Menevian, probably a deep-water deposit, as is indicated by the abnormal size of the eyes of its Trilobites; the lowest bed of étage D probably represents part of the Lingula Flags of Britain. D, α, 1, β

seems to represent the Tremadoc shale of Britain, and, like it, contains pisolitic iron-ore. Representatives also of the Arenig and Bala beds are found. A slight unconformity marks the base of the Silurian. Three Graptolitic zones occur. The lowest, or *Diplograptus* zone, identical with the Birkhill shales, contains thirteen species of Graptolites; the next, or *Priodon* zone (four species), resembles the Brathay Flags; the upper, or *Colonus* zone (five species), resembling the Upper Coldwell Beds of the Lake-district. Above these follow representatives of Wenlock, Ludlow, and probably of the Passage beds. The author, with the evidence of these, discussed the "colonies" theory of M. Barrande, pointing to the non-intermixture of species, notwithstanding the irregular repetition of the zones, the non-occurrence of these colony species in intermediate beds, and other reasons. The stratigraphy and palæontology of several of these colonies was discussed in detail, showing it to be more probable that their apparent intercalation with later faunas is due to repetition by faulting.

3. "On the Pre-Cambrian Rocks of the North-western and Central Highlands of Scotland." By Henry Hicks, Esq., M.D., F.G.S.

The author, after examination, considers the rocks of the following districts to be wholly or in part Pre-Cambrian:—

(1) *Glen Finnan, Loch Shiel to Caledonian Canal.*—In the former district the rocks are gneiss, often massive. In Glen Firmilee is a series which the author regards as newer and Pebidian. At Farofern are quartz rocks which the author identifies with those beneath the limestone in Glen Laggan, near Loch Maree, and probably of Silurian age. At Bannavie is a granite which the author considers to be Pre-Cambrian.

(2) *Fort William and Glen Nevis.*—In this district chloritic schists and gneiss occur, which the author regards as Pebidian.

(3) *Ballachulish, Glen Coe, and Black Mount.*—Chloritic schists and quartzites occur here, followed near Loch Leven unconformably by Silurian rocks. On the east of the Ardsheal peninsula, there is granite, which the author believes to be Pre-Cambrian. Going eastwards from Ballachulish we have slates, probably of Silurian age. In Glencoe are granite-banded felsite, gneiss, breccia, resembling as a whole the rocks of the Welsh Arvonian group. Between the Black Mount and Loch Sullich are traces of a great Pre-Cambrian axis, bringing up the gneissic series; this is traceable also towards Glen Spean and Loch Laggan to the N.E.

(4) *Tyndrum to Callander.*—South and east of the former are gneisses and silvery mica-schists. Crystalline limestones and serpentines are associated near Loch Tay, resembling those in the Pebidian series of North Wales.

The author states that the Silurian (and Cambrian) rocks flank the Pre-Cambrian in lines from N.E. to S.W., and overlap Ben Ledi on the south side. Thus here, as elsewhere, subsequent denudation has removed enormous masses of the more recent rocks, only here and there leaving patches of these in folds along depressions in the old Pre-Cambrian floor.

CORRESPONDENCE.

REPLY TO PROFESSOR PERRY'S COMMENTARY ON PROFESSOR MILNE ON VOLCANOS.

Sir,—Professor Perry has in effect charged me with committing what he calls the "common error of many geologists, who know a little mathematics, of imagining that they can create a mathematical theory for a phenomenon." It would be well if this sort of attempt were a little more common, and that geologists would apply a little more frequently the test of "how much" to their theories. Should errors be made they could be detected and exposed.

But in the present case this rebuke is scarcely merited; for, if your readers will look at Prof. Milne's paper, towards the foot of p. 169, they will see that the effect of pressure in retarding fusion, referred to by his apologist, is not even alluded to by the writer: but solely the effect of the coldness of the bottom water of the ocean in lowering the position of "any given isotherm."

For determining that point I believe that my figures give the simple consequence of the acknowledged law of mean increase of temperature; and I can scarcely be accused of having attempted to "create a theory" thereby. Perhaps however I lacked caution when I used without qualification the expression "melting temperature." So I will explain what I meant by it.

We must, I suppose, accept as a demonstrated fact, that the earth is "as a whole" extremely rigid. We believe that its interior is extremely hot. From these two propositions taken together it follows that the pressure to which the internal parts are subject induces solidity in matter which would otherwise be fluid through heat. This conclusion may be accepted without appealing to experiments, the results of which seem doubtful, respecting the floating or sinking of solid in melted rock. We know further that the superficial layer (which may be called the crust) is solid from cold. But we do not know whether there is a continuous and constantly liquid layer between the crust and that nucleus which is maintained solid by pressure, in spite of its high temperature. For my own part I suspect that there is.

We may feel sure however that at a certain depth the rocks are at such a temperature that, if not already fluid, they would become so if relieved of the superincumbent pressure. This temperature would be the same as that at which they melt at the surface, and is what I meant by "the melting temperature." Used thus, the term is merely a name for a particular isotherm. The temperature, at which the rocks might become fluid in spite of the pressure upon them, is more correctly termed "the melting temperature for the pressure." Prof. Milne's words on which I commented, do not make any reference to this condition.

Perhaps it may be asked—what has the melting temperature at the surface, where there is no superincumbent pressure, to do with the theory of volcanos?

If we suppose the crust to be crumpled by lateral pressure, the vertical pressure beneath the anticlinals must be thereby relieved.

Consequently the heated rocks, if hitherto kept solid by pressure, would enter into fusion at somewhere about this melting temperature, when the pressure was thus removed. I was the first to point this out in 1868. It would seem then that the isotherm, corresponding to the melting temperature at the surface, will near about determine the thickness of the permanently solid crust.

Again, if a fracture were to be opened from below upwards, as might happen in any portion of a synclinal trough, or less advantageously from above downwards in an anticlinal; or if three or more faults radiating from a central vertical, combined with a slight horizontal shift, were to occur; then a funnel would be formed communicating with these hot rocks, and reducing the pressure at that spot nearly to the atmospheric pressure. Immediately the superheated rocks, which probably contain superheated water, if not already fluid, would enter into fusion. Steam would rush upwards, and lava would follow it; and although statical pressure could not perhaps carry this quite to the surface, yet the momentum, acquired by the molten rock in flowing towards and up the funnel, would for a while carry it still further, so that an overflow of lava would take place. But when this momentum was expended, it would sink back again into the funnel.

I have formerly offered some speculations upon these and kindred subjects, fairly open perhaps to the charge of "imagining that I have created a mathematical theory for phenomena." They are contained in three papers published in the Cambridge Philosophical Society's Transactions—viz. "On the elevation of mountains by lateral pressure, with a speculation on the origin of volcanic action": 1868.[1] "On the inequalities of the earth's surface, viewed in connexion with the secular cooling": 1873. And, "On the inequalities of the earth's surface as produced by lateral pressure, upon the hypothesis of a liquid substratum": 1875. These have been all of them placed in the library of the Geological Society.

HARLTON, *8th June.* O. FISHER.

THE "PRE-CAMBRIAN" ROCKS OF ROSS-SHIRE.

SIR,—Now that Dr. Hicks has completed his notice of the Ross-shire rocks, I must ask permission to make one or two comments, since the union of Mr. Davies's name with his own naturally strengthens his case. Mr. Davies's support, however, I venture to say, is more apparent than real; for in some respects no one disputes the conclusion; in others Mr. Davies speaks with reserve; while in others the evidence does not appear to me to have been fully placed before him.

I will therefore recapitulate the points in Dr. Hicks's original paper (Q. J. G. S. vol. xxxiv. p. 811) which I controverted in my notes upon the district (Q. J. G. S. vol. xxxvi. p. 93):—

1. He represented the so-called syenite in Glen Laggan as intrusive in the quartzite and limestone series. I asserted that this rock in the main was not igneous and was not intrusive, but brought up by faults. Dr. Hicks still maintains that it is igneous, but now claims

[1] Reviewed in *Nature*, vol. v. p. 381.

for it a Pre-Cambrian age (Geol. Mag. p. 163)—thus admitting an error. Could Mr. Davies see my specimens, or the rock in the field, I am convinced he would have no doubt that at any rate the bulk of the mass is gneiss.

2. Dr. Hicks asserted that the "newer series" in Glen Laggan (left bank) was not metamorphic. I replied that though in a very different condition from the older series, these rocks were much more altered than is usual with Palæozoic deposits, and were rightly termed metamorphic. The real point at issue does not appear to me to have been made quite clear to Mr. Davies; so, with all respect for his opinion, I must adhere to my statement, supported as it is by good petrologists to whom I have exhibited the specimens and slides.

3. Dr. Hicks asserted that the older series re-appeared in Glen Docherty, and so passed up into Ben Fyn and the mountain group southwards. I stated that of this re-appearance (in itself so improbable) there was no stratigraphical or petrological evidence, and that the microcsopic structure of these rocks in Glen Docherty came much nearer to that of the newer series in Glen Laggan than to any other. Here again I think the evidence has not been fully before Mr. Davies.

The last two points were the foundations of Dr. Hicks's argument, so we need not occupy time by discussing the rocks of Ben Fyn.

I will venture upon two further remarks. One, that it is singular what importance the rocks of Gaerloch have assumed in the interval between Dr. Hicks's first and second paper. In the one they are dismissed merely with a vague allusion, so that I did not think it needful to visit a locality which seemed to have no material bearing on the controversy. Now they are placed in the forefront of the battle. A comparison also of the sections in the two papers (Q.J.G.S. vol. xxxiv. pp. 812, 814, with Geol. Mag. p. 159) will show that important changes, not of detail only, have been introduced (for one at least of which I should like to see the evidence). These changes ought to have been more carefully pointed out to the reader than they have been. The other remark is that Dr. Hicks alludes to my work as hurried. For that accusation I venture to say there is no other foundation than that I did not remain in the district so long as himself. This, indeed, is true; but to test a theory ought not to require so long a time as to invent it. At any rate I remained long enough to convince me that the above three assertions of Dr. Hicks could not be established. On that point no amount of delay would have altered my opinion. Further, to the work in the field, the study of about forty microscopic slides, from most carefully selected specimens, has been added. As it seems to me, the author who first makes a rock intrusive in Silurian beds,[1] and then (without again visiting the locality, be it noted) regards it as Pre-Cambrian (cf. Q.J.G.S. vol. xxxiv. p. 814 with Geol. Mag. 1880, p. 159) is more open to the charge of hasty work.

T. G. Bonney.

[1] In using the term admitted by Dr. Hicks, I do not wish to commit myself to any opinion as to the age of the "newer series." It is possible that there may be very much Pre-Cambrian rock in the Scotch Highlands: my contention is that Dr. Hicks's proof of this is erroneous.

REPLY TO PROFESSOR HULL.

Sir,—You were good enough to publish in the February Number of this Magazine a letter from me on the subject in dispute between Prof. Hull and Mr. Wilson. To this letter Prof. Hull has referred in April, page 185, and his remarks seem to call for some reply.

The point of my letter was to show that the north and south movements which have affected the Carboniferous rocks of Central England, and presumably the parallel movements in other localities, originated before that portion of the Permian period which is represented by the Marlslate and Magnesian Limestone. The evidence I reiterated on this point appears to me conclusive, and Prof. Hull in his letter makes no attempt to refute it, but shows a disposition to introduce personal questions.

At the conclusion of my letter I expressed an opinion which in no way affects the gist of my argument, but which appears somewhat to have irritated Prof. Hull, namely, the opinion that the Permian and Trias are not separated by any important unconformability.

This was certainly weak on my part, because it raises the question what is and what is not an important unconformability, and gives my opponent the opportunity, which he has not been slow to utilize, of raising a side issue. On this point I will content myself with saying that my opinion has not been formed on local phenomena only, but after the consideration of all the palæontological and physical facts bearing on the question, and with due regard to the opinions of our fathers Sedgwick, Phillips, and Murchison.

Once more let me recur to the point I am contending for. The relation of the Carboniferous rocks to the Permians along the eastern boundary of the exposed portion of our Coal-field clearly proves that the north and south strike was determined before the Permian period. This must have been produced by north and south movements accompanied by denudation, and therefore I believe that *these movements* and, in the absence of any conclusive evidence [1] to the contrary, *the parallel movements in other districts*, originated before the Permian period. As evidence on this point, I send a photograph which I wish could be reproduced as a woodcut along with this letter. It was taken in a railway cutting at Kimberley,[2] which extends in an east and west direction; the lower beds dipping nearly east at a high angle are Carboniferous shales and sandstones, while the upper and nearly horizontal beds are Permian breccias and marls. This section may be taken as typical of the relation which the Permian rocks bear to the Carboniferous along the eastern edge of the exposed portion of our basin, and therefore proves in the most convincing manner that the north and south movements which assisted in the formation of this basin originated before the Permian period.

J. J. Harris Teall.

9, All Saints' Street, Nottingham.

[1] Of course I am acquainted with Prof. Hull's paper, Q.J.G.S. vol. xxiv. p. 332.
[2] The section here figured is referred to by Mr. Wilson, Q.J.G.S. 1876, p. 533.

THE TERM "SCHIST."

Sir,—Undoubtedly Mr. Rutley is right in his etymology of the word "schist," and can produce authorities for the sense in which he proposes to use it; but notwithstanding this, and Mr. Allport's support, I must confess myself a schismatic.

But as authority has been named, I will also quote one by way of adding to the confusion, "It would be well to describe no structure as *slaty* or *fissile* except cases of transverse cleavage" (Sedgwick, Structure of Large Mineral Masses, Tr. G. S. ser. 2, vol. iii. p. 480). Mr. Rutley says (p. 239), "I use *schistose* and *fissile* as convertible terms when the fission is not of that perfect kind which characterizes *slates* and *shales*." I confess, indeed, that I can see no reason etymological or otherwise why, if the term "schist" is to be extended beyond metamorphic rocks, those with slaty cleavage should be excluded.

"The correct application" of these terms must, no doubt, to some extent "depend on usage," but then we must be satisfied that usage has not proceeded from inaccuracy and will not give rise to inconvenience. Surely it is always lawful to fix the sense of a term which previously has been rather vague. This Prof. Jukes attempted to do, as I venture to think, wisely, well, and intelligibly. Schists, then, in his sense (and I believe it one very commonly in use among geologists) are metamorphic rocks with a fissile structure due to the arrangement of their mineral constituents. Schistose rocks are those which possess this property or seem to possess it; while slates have the property of cleavage; shales of lamination. Thus all schists are in some sense foliated rocks, though it is possible a foliated rock (as sometimes happens with gneiss) may not be strictly a schist. With such a limitation of the term we know what a writer means. Just think of the confusion which is caused when, on meeting with the word schist, we are uncertain whether the author is speaking of a rock that has undergone great chemical alteration or practically none at all. Seeing then that (as it seems to me) Prof. Jukes's limitation supplies us with a term which we really want, I trust that no attempt will be made to extend the name "schist" beyond the group of metamorphic rocks.

T. G. Bonney.

ECCENTRICITY AND GLACIAL EPOCHS.

Sir,—There are some points in Mr. Hill's remarks as to the causes of a Glacial Epoch which I think require rectifying. He admits that the total amount of heat radiated by the sun and received by any portion of the earth in any one year is a fixed amount. In his letter in your issue of April, he admits as probable, that the heat given up in the formation of snow, being disengaged in the upper regions produces little effect at the ground. Now, granting these, I think it is clearly demonstrable that a Glacial Epoch may be caused by an increased snowfall. For say in any region we have through increased eccentricity a fall of two feet of snow as against a fall of one foot before such increase of eccentricity. Then, with a fixed amount of heat we have double the work to do in reconverting this snow into water and vapour. Hence, we must conclude that the available heat influencing the climate is decreased by exactly the amount expended in this work, and therefore a continuance of the greater snowfall must have the effect of lowering the average temperature of the climate.

On page 17 of your January Number, Mr. Hill argues that owing to increased radiation being greater in proportion to the increase of temperature, therefore, that this may be a cause of glaciation. He apparently ignores the fact that if radiation is increased in greater proportion by a rise in the temperature, it is decreased in like proportion by a fall, and that therefore the total annual radiation with a fixed amount of heat received is therefore also a fixed amount. If this total radiation was not a fixed amount, would it not have the effect in high latitudes, where there is a great difference in quantity of heat received between summer and winter, of causing a Glacial Epoch? And if so, how is it that with this cause of glaciation the action does not spread towards the equator as it should do if so caused?

Jos. Greenwood.

Durham, *June 1st*, 1880.

"POST-GLACIAL."

Sir,—Might I ask the anonymous reviewer of my pamphlet memoir on the Colchester District[1] to state in what esoteric sense he uses the word Post-Glacial; at what point in the northward recession of Arctic conditions he draws the chronological line between the Glacial and Post-Glacial epochs; and why he supposes that those conditions obtained outside of the Arctic Circle at the time of formation of the beds I have described as Post-Glacial in the work in question.

The mammalia and most of the invertebrata are present in the middle and lower terraces of the Thames Valley, whilst *Unio littoralis*, three of the *Helices*, and several of the Coleoptera indicate the climate of more southern latitudes, and *Corbicula fluminalis* is a sub-tropical species.

Further deposits have been formed under the existing geographical conditions as valley brickearths and foreshore mud and sand, upheaval of the latter to about 30 feet having taken place, with an equal extent of deepening of the valleys in consequence.

Harleston, *13th June*, 1880. W. H. Dalton.

[1] Geol. Mag. June, 1880, p. 279.

THE CUDGEGONG DIAMOND FIELD.

Mr. Norman Taylor, whose paper, bearing the above title, was published in the Geological Magazine, 1879, Vol. IX. pp. 399–412, and pp. 444–458, requests permission to make the subjoined corrections, viz.:—

Page	400,	line	18	from top,	*for* "C. J. Wilkinson," *read* "C. S. Wilkinson."
,,	401,	,,	23	,, bottom,	*for* "Wialdra Reedy Creek," *read* "Wialdra *or* Reedy Creek."
,,	402,	,,	17, 18	,, top,	*for* "Hapdash," *read* "Slapdash."
,,	402,	,,	21	,, ,,	*for* "occurs," *read* "occurring."
,,	402,	,,	4	,, bottom,	*for* "40 ft. more," *read* "40 feet *or* more."
,,	403,	,,	13	,, top,	"descending order," *means* "the order in which they occur in descending the river."
,,	407,	,,	7	,, bottom,	*for* "greensand," *read* "gemsand."

OBITUARY.

REV. JAMES CLIFTON WARD, F.G.S.

The announcement of the death of the subject of this notice must have been to most of his many friends a shock wholly unexpected, both on account of the early age at which he passed away, and the very brief illness which preceded his decease.

After a weakly boyhood, he entered the Royal School of Mines as a student in 1861, and gained the Edward Forbes Medal and prize of books in 1864. In the following year he joined the Geological Survey, and was sent down to Yorkshire. He worked there on the Millstone-grit and Lower Coal-measures in the neighbourhoods of Sheffield, Penistone, Huddersfield, Halifax, and Leeds. Though Ward was never of robust appearance, he had obviously increased both in height and breadth since leaving the School of Mines, when seen by the present writer in 1868; so well had the laborious but healthy work of the Survey agreed with him. While in Yorkshire he always preferred Millstone-grit to Coal-measure work, and his paper read before the Geological Society in 1869 marks the scene of his last labours in that county. It is "On Beds of supposed Rothliegende Age near Knaresborough;" and in it he proves the Millstone-grit affinities of the beds in question, known as the Plumpton Grits.

In 1869 he was transferred to Keswick, and the change from a colliery district to a locality not only devoid of coal-pits, but one in which wild Nature puts forth all her charms, was in the highest degree pleasing to him. At Keswick his activity became two-fold. His Survey work and its results are now represented by his Geological Survey Memoir on "The Geology of the Northern Part of the English Lake District" (published in 1876), and by numerous maps and sections. He also contributed many papers to the Geological Society, and to various periodicals, bearing on the structure of the Lake Country. Of these may be mentioned, in the first place, two on its glaciation, entitled: "The Origin of some of the Lake Basins of Cumberland," Q.J.G.S. 1874; and, "The Glaciation of the Southern Part of the Lake District, etc.," Q.J.G.S. 1875. In both papers the origin of the lakes is discussed, and (as regards the English Lake Country) the original investigations of the author confirm the views so long held by Professor A. C. Ramsay. These papers are illustrated by sheets of sections of the highest interest and value, and, to make the work more complete, the results of a series of soundings carefully taken on most of the lakes by this indefatigable worker are also given.

In the years 1875 and 1876, and more recently, microscopical examination of the rocks of the Lake District occupied much of his time. Of papers on this subject I may here note one "On the Granitic, Granitoid, and Associated Metamorphic Rocks of the Lake District," the first part of which appeared in the Q.J.G.S. for 1875, and the second in the volume of the same periodical for 1876. Another paper is entitled, "Notes on the Comparative Microscopic Rock-Structure of some Ancient and Modern Volcanic Rocks," and may be seen in the Q.J.G.S. for 1875. Among his latest contributions to geological literature may be mentioned "Notes on the Geology of the Isle of Man," which appeared in the Number of this Magazine for January last. Of course the papers hitherto noticed are but typical samples of his work, and not an exhaustive list of his productions.

But the most characteristic side of his untiring energy, and perhaps its most important one, was the zeal with which he worked for the diffusion of scientific knowledge while in Cumberland. Before leaving Yorkshire he had written a small elementary book on Physics, and one of the first-fruits of his educational activity at Keswick was a similar work on Geology, composed of nine lectures delivered in the first place before a school audience, and secondly before the Keswick Literary Society. Being simple, clear, and free from unnecessary technicalities, his lectures soon became popular, and the lecturer himself acquired influence.

But as the originator and main support of the "Cumberland Association for the Advancement of Literature and Science," and of most of the local societies connected with it, he accomplished a work which it may be hoped will not now be suffered to languish, but will remain a lasting monument of his beneficent activity. A glance at the outer cover of the Transactions of the Cumberland Association (Part iv. was published at the beginning of this year), shows the date at which each of the associated societies was founded, and discloses the fact that only one of them—Whitehaven—existed before Ward's appearance in the county. The dates of the others vary from Keswick, 1869, to Silloth, the latest, 1879.

He married at the beginning of the year 1877, and very shortly after left the Lake Country to do field-work in the lone, bare district of Bewcastle, on the Lower Carboniferous rocks, wintering, however, in Keswick as before. But on finishing the Bewcastle work he made preparations for entering the Church, and was licensed to the curacy of St. John's, Keswick, in December, 1878. He was as successful in his new duties as he had been as a geological surveyor, and was appointed at the beginning of this year to the vicarage of Rydal, which, to a man of his tastes, must have seemed preferable to the most dignified and lucrative post in a locality inferior in natural charms and poetical associations; even apart from its nearness to Keswick. But he was scarcely established in his new home when a brief illness, which only at the last seemed dangerous, caused his departure, at the age of thirty-seven years, for "the land of the leal," leaving behind a widow and two children.

His sweet and genial disposition, and the absence in him of the least approach to the temper of the dogmatist, caused him to number among his friends men of every shade of speculative opinion. It was this amiability, in addition to his ability as a lecturer, and the single-mindedness of his desire for the spread of knowledge, which made him so successful in connexion with the Cumberland Association, when the simple fact of his not being a Cumbrian by birth would have been fatal to any merely active and zealous man. For the Cumbrians, like their Scottish neighbours, have no urgent need to pray,—"Lord! gie us a gude conceit o' oursels;" and would certainly have resented any approach to a "gude conceit" of himself in any stranger taking upon himself a prominent position as a reformer in their county. His success, therefore, in that capacity, is perhaps the most remarkable achievement adorning the short but admirable life of James Clifton Ward.—T. V. H.

PROF. D. T. ANSTED, M.A., F.R.S., F.G.S., ETC.

Born 1814; Died 1880.

By the death of Prof. Ansted, geological science has lost one of its cultivators, both in its scientific aspect, and also in its practical bearings.

Born in 1814, he was educated at a private school in London and afterwards at Cambridge, where he took high Mathematical honours as a Wrangler in 1836, and attained his M.A. in 1839. For some time he was a Fellow of Jesus College. In 1840 he became the Professor of Geology at King's College, London, and in 1845, Lecturer on Geology at Addiscombe, and Professor of Geology at the College of Civil Engineers, Putney. About this period (1844), he accepted the post of Vice-Secretary of the Geological Society of London, and Editor of the Quarterly Journal of the Society. In 1868 he was appointed Examiner in Physical Geography to the Science and Art Department.

Since 1848 he has been chiefly occupied as a Consulting Mining Engineer. Prof. Ansted has written numerous works on Geology and Physical Geography, as well as contributing to most of the leading scientific journals of the day.

Henry Ludlam, F G.S.—We have also to notice with deep regret the death (on June 23rd) of our friend Mr. Henry Ludlam, F.G.S., who specially devoted himself to the study of Mineralogy, and whose private collection is the finest in London both in foreign and British species. It includes both the Turner and Nevill Collections, as well as the choicest minerals from many other well-known Cabinets.

We regret to notice the death of Mr. W. H. Holloway, F.G.S., of the Geological Survey of England and Wales. Mr. Holloway joined the Survey in 1869, and received his training in field-work from Prof. Judd, on the Liassic and Oolitic district described in the Memoir on the Geology of Rutland. Since this time he has been continuously employed in mapping these rocks and overlying Drift deposits in Lincolnshire and Nottinghamshire, particularly in the neighbourhood of Grantham and Sleaford, where his work was carried on in great detail and with every attention to minute accuracy. Mr. Holloway was a Member of the Geologists' Association, and was one of the directors at the excursion made to Grantham and Nottingham, at Easter, 1876.

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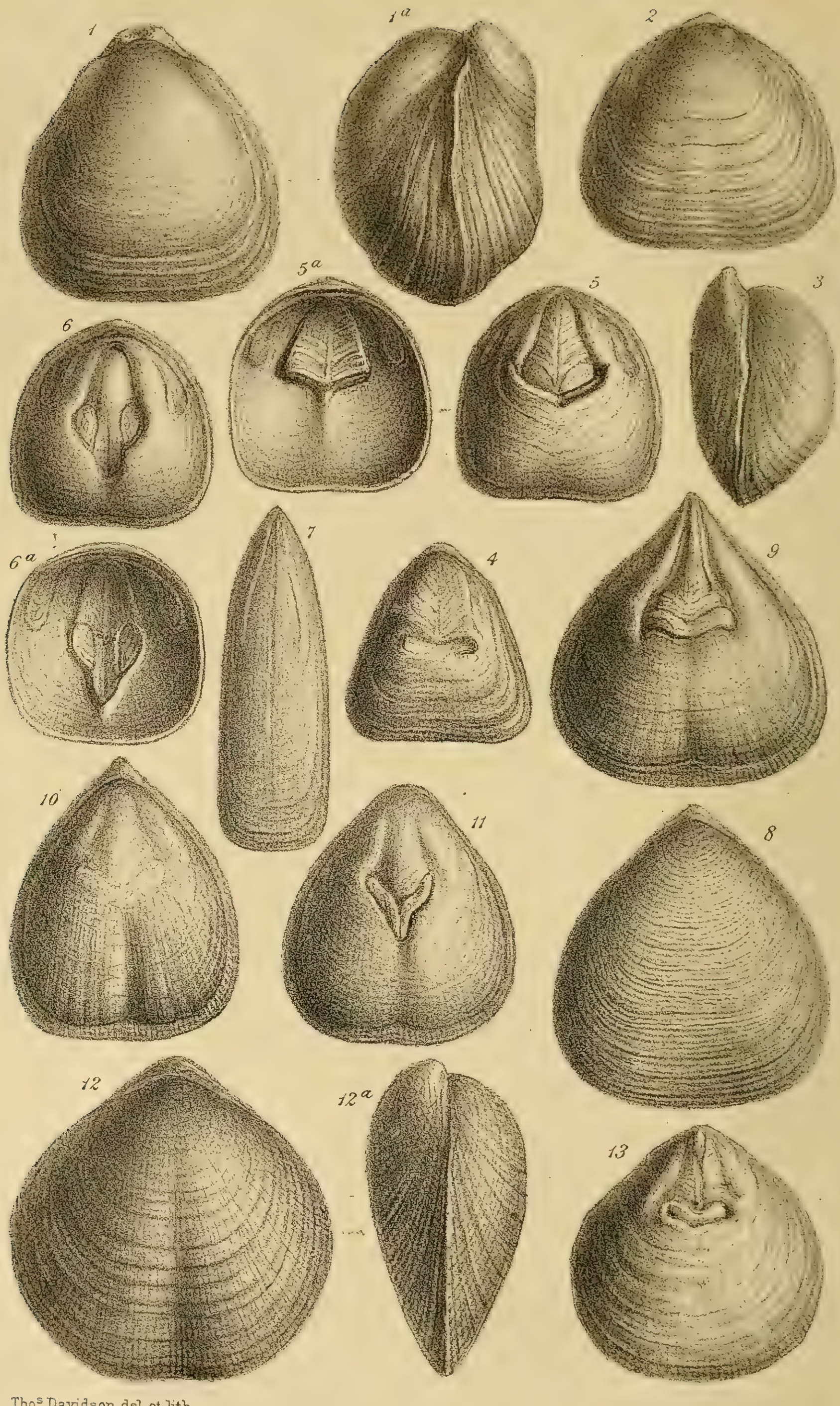

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THE

GEOLOGICAL MAGAZINE.

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No. VIII.—AUGUST, 1880.

ORIGINAL ARTICLES.

I.—On the Species of Brachiopoda that Characterize the "Grès Armoricain" of Brittany, together with a few Observations on the Budleigh Salterton "Pebbles."

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

(PLATE X.)

During the past twelve months I have devoted much time to the careful study of those questions that relate to the probable source of derivation of the sandstone and quartzite boulders or "pebbles" that were drifted and accumulated in the neighbourhood of Budleigh Salterton by "Bunter" waters. The detailed results of my investigations will appear in my forthcoming Devonian Supplement. Cornwall and North Devon having been pointed at, as a probable source of derivation, I considered it necessary to study the rocks and fossils that exist in those portions of Great Britain, as well as those that occur in Normandy and Brittany, on the other side of the Channel.

After some little trouble I was able to assemble, for examination, numerous examples of rock, and all the specimens and species of Brachiopoda that had been collected from the Lower Silurian deposits of the south of Cornwall, and which were kindly lent to me out of the museums of Penzance, Truro, the School of Mines, London, the Woodwardian Museum, Cambridge, the Museum of Edinburgh Geological Society, as well as from various other sources. Mr. Peach, the father of Cornish Lower Silurian geology, and first discoverer of its fossils, afforded me every facility and information within his power, as did also Mr. J. H. Collins, of Truro.

After a long and careful examination of all these Cornish specimens, and a lengthened correspondence upon the subject with M. de Tromelin, I found that they represented five species only, or that were identifiable, viz. *Strophomena grandis*, *Orthis Scotica*, *Orthis calligramma*, var. *O. Berthosi*, var. *Cornubiensis*, and *O. Budleighensis* (the shell so often confounded with *Orthis redux*, of Barrande).[1] I also examined with care the Devonian rocks of North

[1] I have devoted a quarto plate to the illustration of the Cornish species, and four to the delineation of those that occur at Budleigh Salterton.

Devon, and the Hangman grits in particular, and arrived at the conclusion that the Devonian "pebbles" accumulated at Budleigh Salterton could not have been derived from North Devon, and especially from the Hangman grits, which contain very few Brachiopoda besides *Stringocephalus Burtini*, a species that has not hitherto been found in any of the "pebbles" above alluded to.

In 1864, Messrs. Vicary and Salter attributed the Budleigh Salterton "pebbles" to the Silurian period. In 1869 I showed that while a portion of the pebbles were unquestionably Silurian, another portion were undoubtedly Devonian.

Since then, M. Gaston de Tromelin and M. Lebesconte[1] have shown by their elaborate study of the Silurian and Devonian rocks of Normandy and Brittany that the Lower Silurian pebbles of Budleigh Salterton were distinctly referable to two well-defined stages or horizons. First to the "Grès Armoricain," which, according to M. de Tromelin, would correspond with our Lowest Llandeilo, or perhaps, even "Stiper Stones," and which in Brittany, as well as at Budleigh Salterton, would be characterized by the presence of *Lingula Lesueuri, L. Hawkei, L. Salteri* and *Dinobolus Brimonti*—species that have not hitherto been discovered in any rock, *in situ*, in Great Britain.

Above the Grès Armoricain, in Brittany, we find slaty schists with an occasional band of yellow sandstone, in which Brachiopoda are abundant; but, with the exception of *Orthis Budleighensis*, which abounds at Andouville and La Hunandiere, I could find among the numerous specimens kindly lent me by M. Lebesconte no other species with which I was acquainted that occurred likewise in the Budleigh Salterton pebbles.

We must, however, not omit to observe that at La Couyère in Brittany, according to M. M. Rouault. M. de Tromelin, and M. Lebesconte, black slates occur full of flattened distorted specimens of a large *Orthis*, the type of Rouault's *Orthis Berthosi*. Thanks to M. Lebesconte I have been able to examine a number of specimens of this flattened species. It is marginally nearly circular, measuring some 19 or 20 lines in length and breadth, the surface of the valves covered with numerous fine radiating raised lines or riblets, crossed at intervals by concentric lines of growth. The typical form of Rouault's species has not, that I am aware of, been hitherto discovered in Great Britain.

Above the schists we find the sandstones and quartzites of May, St. Germain-sur-Ille, La Bouexière, and other places, so well described by the French geologists above named. This "Grès de May" has long been considered to be referable to the Caradoc, and in it are found immense numbers of internal casts and impressions of *Orthis Budleighensis*, as well as of a small variety of *Orthis Berthosi*, to which I gave the varietal designation of *erratica*,

[1] Assoc. Franc. pour l'avancement de la Science, Congrès de Nantes, 1875, Bull. Soc. Linn de Normandie, 3 ser. vol. i. p. 5, 1877; Congrès du Havre, 1877, Bull. Soc. Geol. de France, 3 ser. t. iv. p. 583, 1876; and M. J. Moriere, Note sur la grès de Bagnoles, Bull. Soc. Linn. de Normandie, 3 ser. vol. ii. 1868.

and which along with *Lingula Morierei*, Tromelin, are all species that occur in the quartzites and sandstone pebbles of Budleigh Salterton.

Above the "May Sandstone," in Brittany, we come upon a deposit of slaty schists, which, however, contain but a few Brachiopoda, and these in an unsatisfactory and crushed or distorted condition.

The Silurian Brachiopoda hitherto discovered in the Budleigh Salterton pebbles may, therefore, be arranged in the following stratigraphical order:

Grès de May—Caradoc	*Lingula Morierei*, Tromelin. *Terebratula?* sp. *Nucleospira Vicaryi*, Dav. *Orthis Berthosi*, var. *erratica*, Dav. *Orthis pulvinata*, Salter. *O. Valpyiana*, Dav. *O. Budleighensis*, Dav.
Grès Armoricain—Lowest portion of Llandeilo.	*Lingula Lesueuri*, Rouault. *L. Hawkei*, Rouault. *L. Salteri*, Dav. *Dinobolus Brimonti*, Rouault, sp.

A *Lingula* much resembling *L. crumena* has also been discovered at Budleigh Salterton, but it may possibly be a malformation of *L. Hawkei*. Above the Lower Silurian deposits of Brittany, we have a large development of Devonian sandstones, quartzites, and limestones, identical in mineral composition and colour with that of the "Pebbles" of Budleigh Salterton; but it is in the Lower Devonian Sandstone of that country, or that named "Grès à *Orthis Monnieri*" by M. de Tromelin, that we find the larger number of species that occur likewise in the Budleigh Salterton pebbles. The *Orthis Monnieri*, Rouault, is the shell which I described in 1869 by the name of *Orthis Vicaryi*.[1] It occurs in the yellow sandstone at St. Aubin d'Aubigny and at Gahard. We have, besides this species, in the same rock, *Spiriferina octoplicata*, *Rhynchonella elliptica* and others.

I have made out some twenty-eight species of Devonian Brachiopoda as occurring in the Budleigh Salterton pebbles, and M. de Tromelin has pointed out among them the presence of *Orthis Hamoni*, Rouault, a species recently figured by Mr. Bayle, and which occurs also in the Devonian sandstones of Brittany.

It is quite true, as was remarked by Mr. Peach and Mr. Etheridge, that we find in the Lower Silurian rocks of Cornwall bands of a light grey quartzite, with casts and impressions of *Orthis Budleighensis*, and that pebbles of a similar nature and with the same fossil are to be found at Budleigh Salterton; but when we consider that out of the twelve species of Silurian Brachiopoda that are found in the "pebbles," only one, or at most two, of the species occur in the

[1] Out of the thirty-six new species of Brachiopoda merely named or briefly described by Marie Rouault, only one was figured by him, viz. the *Orthis Berthosi*. This want of illustrations has been the cause of much unavoidable misconception and errors in identification. The public had not even the advantage of being able to consult the original types, which are not exhibited in the Museum at Rennes.

Cornish rocks, it is evident that we must look to other sources for the derivation of the great bulk of the Silurian pebbles accumulated at Budleigh Salterton. It is probable that but a proportionately small number, if any, of the pebbles were actually drifted from Cornwall to South Devon, and that it is to France, or to an extension of Silurian and Devonian rocks that may have existed in the Channel and nearer to Devonshire, that the pebbles now accumulated near Budleigh Salterton were mainly derived. This is likewise the view taken by M. de Tromelin and M. Lebesconte, and is reciprocated by most of our British geologists who have interested themselves in the question.[1]

It is also remarkable that quartzite pebbles exactly similar to those that occur at Budleigh Salterton and containing *Orthis Budleighensis* have been found in drift deposits in Warwickshire, near Leicester, near Nottingham and Birmingham. Others with *Lingula Lesueuri* in Warwickshire, and near Birmingham. While quartzite pebbles with *Sp. Verneuilii* have been picked up near Birmingham, and one with a *Discina Vicaryi* on the Chesil Bank.

Dinobolus Brimonti, Rouault sp. Pl. X. Figs. 1—6.

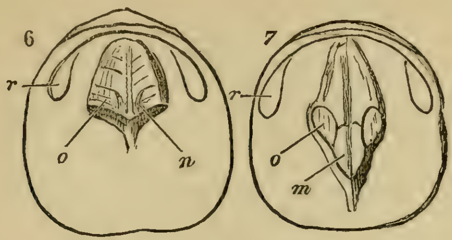
Lingula Brimonti, Rouault, 1850. *Lingula Hawkei*, Salter and Dav. (not of Rou.).

I never felt satisfied that this remarkable fossil belonged to the genus *Lingula*, and both M. de Tromelin and Prof. Bayle hinted to me that it was in their opinion not a species of *Lingula*, and that a new genus would have to be created for its reception.

Thanks to the liberality of M. Lebesconte, I have recently been able to study a large series of bivalve specimens as well as finely preserved internal casts of both valves, and at once perceived that the species possessed all the characters of Hall's genus *Dinobolus*, and of which genus Prof. King and myself had given an elaborately illustrated description in the Quarterly Journal of the Geological Society, vol. xxx. 1874. We can therefore dispense with burdening the nomenclature with another new genus. *Dinobolus Brimonti* is very variable in its shape, but generally more or less quadrate, with rounded angles; sometimes it assumes a triangular form (Pl. X. Fig. 4). The dorsal valve is the deepest and most convex or inflated, a median longitudinal depression being observable in the ventral valve. The beak projects moderately (Fig. 3), and although smooth exteriorly, the surface of both valves is strongly marked with deeply indented concentric lines or projecting ridges. In the interior of the ventral valve, we observe a well-defined platform on which are situated the lateral and anterior muscular scars *o* and *n*, as well as the crescent *r*. On the interior surface of the dorsal valve, in addition to the anterior and median V-shaped muscular scars *o* and *m*,

[1] M. Lebesconte informs me that fossiliferous sandstones and quartzites have been found in the following localities, in Normandy and Brittany—1. *Grès Armoricain*, Pontréan, Plèchatel, Guichen, Sion, Chateaubriant, Provostais, Laillé. 2. *Grès de May*, La Bouexière, St. Germain-sur-Ille, May, Jusques. *Grès Devonien*, Gahard, St. Aubin d'Aubigné.

we observe the crescent *r*, and which will be clearly seen in the figures of our Plate.

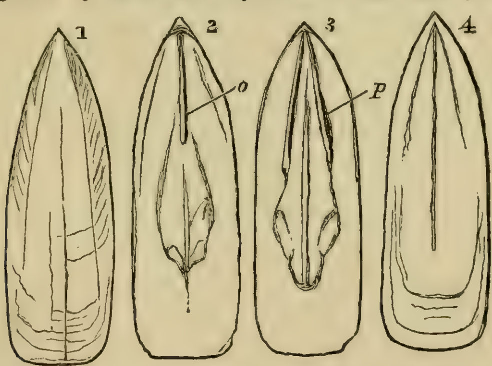


DINOBOLUS BRIMONTI.
6. Interior surface of ventral valve. 7. Interior surface of dorsal valve.
o lateral scars, *n* anterior scars, *m* median scars, *r* crescent.

I may also note that subsequently to the publication of Professor King's and my memoir on the *Trimerellidæ,* Prof. Fred. Schmidt discovered in a light yellowish limestone at Laisholm in Russia (his Schicht 5) a number of internal casts of a small species of *Trimerella,* and at Werden in the same country (in his Schict 6) a species of *Monomerella.* So that examples of this important family of Brachiopods are now known from Sweden, Russia, France, England, Canada and the United States, and will no doubt be discovered in other places. The *Dinobolus Brimonti* is the most ancient representative of the family with which we are at present acquainted.

2. LINGULA? LESUEURI, Rouault. Pl. X. Fig. 7.

This very remarkable lanceolate species is now well known, and has been figured by Salter and myself. It has been questioned by



Figs. 1, 2, 3. *Glottidia Palmieri*, Dall (recent).
1. Exterior. 2. Interior of ventral valve. 3. Interior of dorsal valve. *o. p.* septa.
4. *Lingula Lesueuri*, Rouault, Lower Silurian.

M. de Tromelin whether it is a true *Lingula.* It entirely resembles in external shape and size *Glottidia Palmieri,* Dall, a shell that lives

5. *Lingula Lesueuri*, with peduncle, Budleigh Salterton.

in the Gulf of California, and which is characterized by one short median septum in the ventral valve (Fig. 2, *o*), and two diverging ones in the dorsal one (Fig. 3, *p*). M. de Tromelin says that he has seen similar septa in both valves of *Lingula Lesueuri*, and indications of them are visible on the internal cast, Fig. 4. It will, therefore, remain a question for further consideration, whether the Lower Silurian species might not be referable to Dall's genus *Glottidia ?* I may also mention that Mr. Vicary has recently found in a Budleigh Salterton pebble a specimen of *Lingula Lesueuri*, with its peduncle fossilized, Fig. 5. This is a remarkable occurrence, although not unique.

Lingula Lesueuri is tolerably abundant in the Armorican Sandstone at Pontréan, Guichen, and Sion in Brittany. M. Moriere has found it in beds of a similar age at Bagnoles—and M. de Tromelin has recently discovered it at Lairoles, near Roquebrun (Herault).

3. Lingula ? Hawkei, Rouault. Pl. X. Figs. 8—11.

Lingula Rouaulti, Salter and Davidson.

This remarkable species differs much from the common shapes of *Lingula*, although, as far as I could ascertain, it possesses similar muscular impressions, as will be seen by a glance at Figs. 9, 10, 11, of our Plate. I am, however, uncertain if it should not be removed from *Lingula* proper; but this must remain a question for future discussion. It is remarkably pear-shaped, and tapers a good deal at the beak. There appears also to exist on the internal cast of the ventral valve a narrow flattened margin, as well as a narrow median longitudinal depression, while the lateral portions of the casts are longitudinally striated (see Pl. X. Figs. 9, 10). In external shape and character *L. Hawkei* is well distinguished from *L. Lesueuri*, *L. Salteri*, as well as from *Dinobolus Brimonti*. The exterior surface of the valves are marked with numerous close and fine concentric lines (Pl. X. Fig. 8). It appears abundant at Pontréan (Ille-et-Vilaine).

4. Lingula ? Salteri, Dav. Pl. X. Figs. 12, 13.

Lingula Salteri, Dav. Sil. Mon. p. 53, pl. i. figs. 27–29, 1866.

When I described and illustrated this remarkable species in 1866, my material was so scanty and incomplete that I felt somewhat uncertain with respect to its characters, or the genus to which it belonged. Since then M. Lebesconte has found several good examples of the shell at Pontréan, in Brittany. One perfect bivalve specimen, Pl. X. Figs. 12, 12*a*, is almost circular, 21 lines in length and breadth by 11 in depth, and shows that its valves are moderately convex, and of about equal depth, the dorsal one most convex at the umbo, with slight mesial longitudinal depressions commencing at about half the length of the shell, and widening to the front. The ventral valve is moderately convex, flattened, or slightly depressed from about its middle to the front. Beak moderately projecting and incurved. Surface of both valves faintly and closely radially striated; striæ thread-like, and intersected by numerous concentric lines of growth. On the internal cast of the dorsal valve the central muscular scars are sharply defined (Pl. X. Fig. 13).

This species occurs at Pontréan. In his paper (Congrès de Nantes, 1876) M. de Tromelin mentions having found it in the Grès Armoricain of Pontréan.

It is probable that when the exterior characters of this species are better known, that it will be necessary to separate it from *Lingula* proper, although it will retain its place among the *Tretenterata*. The details we have been able to add from the study of the French specimens of the four Armoricain species will materially add to what was previously known of their characters, and little by little we may be able to clear up their history. *Lingula Salteri* does not appear to have been noticed by M. Rouault.

EXPLANATION OF PLATE X.

FIG. 1 to 6. *Dinobolus Brimonti*, Rouault, sp. 5. Internal cast of ventral valve. 5*a*. Interior of same valve, reproduced by means of gutta-percha. 6. Internal cast of dorsal valve. 6*a*. Interior of valve, reproduced by means of gutta percha.

,, 7. *Lingula Lesueuri*, Rouault, a large typical specimen.

,, 8 to 11. *Lingula Hawkei*, Rouault. 8. Exterior. 9, 10. Internal casts of ventral valve, to show muscular impressions, and flattened margin. 11. Internal cast of dorsal valve, showing muscular impressions, and flattened margin.

,, 12 to 13. *Lingula Salteri*, Dav. 12. A perfect bivalve specimen. 12*a*. Showing the two valves in profile. 13. Internal cast of ventral valve, showing central muscular impressions.

All the specimens are from the "Grès Armoricain" of Pontréan in Brittany, and are in the Collection of M. Lebesconte of Rennes.

II.—NOTE ON THE GENUS *CAUNOPORA*, of Phillips.

By Prof. DR. FERD. ROEMER,
of the University of Breslau; For. Memb. Geol. Soc. Lond.

UNDER the name of *Caunopora placenta* Prof. Phillips described a fossil which is very common in the Devonian Limestone of South Devon, and which Mr. Lonsdale had described before as *Coscinopora placenta*. It forms amorphous or spheroidal masses composed of thin concentric laminæ, and perforated by small flexuous or vermiform tubuli.

The genus has since become the subject of repeated discussion by various authors. All of them agreed in the conclusion that the texture of the main mass of the genus is very similar to that of *Stromatopora concentrica*, which is found associated with *Caunopora* in the same limestone. The difficulty was how to account for the flexuous vermiform tubuli, which perforate the main mass at irregular distances, and in various directions. The greater number of writers on the subject regarded the tubuli as canals by which the communication between the different parts of the body was effected, or at least as essential organs of the species. So long ago as 1844 I expressed the opinion[1] that *Caunopora placenta* of Phillips was nothing else than *Stromatopora concentrica*, which has surrounded and overgrown the stems of *Syringopora*. In a recent elaborate memoir on the minute structure of *Stromatopora* and its allies,[2] by Professor H. Alleyne Nicholson and Dr. James Murie, these authors deny that the tubes could belong to *Syringopora*, because they have decidedly not the infundibuliform tabulæ so characteristic of *Syringopora*, and come to the conclusion that the tubes essentially belong to the *Stromatopora*-like body, which is therefore entitled to generic distinction as *Caunopora*.

My own observations confirm entirely the statement that the tubes have not the internal structure of *Syringopora*, but are hollow, and can therefore not belong to that genus; but the inference drawn from this fact, viz. that the tubes are an essential part of the *Stromatopora*-like body, is erroneous. A number of specimens of *Caunopora placenta* from the Devonian beds of Gerolstein in the Eifel, which exactly agree in structure with those from the limestones of South Devon, show distinctly that the tubes belong to *Aulopora repens*. This little creeping Coral attached itself on the surface of *Stromatopora concentrica*, and when a new concentric layer of *Stromatopora* was forming, it extended its calices upwards in tubes to prevent itself from being entirely covered, and finally killed by the *Stromatopora*. When other layers of the latter followed, the calices of *Aulopora* continued to grow upwards. On the surface of the uppermost layer of *Stromatopora* the calices of *Aulopora* appear as circular openings with a distinct and projecting rim. This relation in growth of the two species is particularly obvious in such specimens from Gerolstein which show a mass of *Alveolites suborbicularis*, with a network of *Aulopora repens*, on the surface, and which are besides partly covered with a thin layer of *Stromatopora concentrica*. The network of *Aulopora* is, in such specimens, occasionally partly free and partly covered with the thin layer of *Stromatopora*. Where it is covered, the calices of *Aulopora* appear as circular openings with a projecting rim on the surface, just as H. A. Nicholson and Dr. J. Murie[3] have figured them in *Stromatopora* (*Caunopora*) *perforata* from the Corniferous Limestone of Ontario. I have no doubt that in this Canadian species the circular openings are equally the calices of *Aulopora*, as in the Eifel specimens.

In thick masses of *Caunopora* the vertical tubes do not necessarily all belong to the same individual of *Aulopora*, but different colonies of these little creeping corals attached themselves repeatedly to the surface of the succeeding concentric layers of *Stromatopora*, and were covered by the following one. In fact, on vertical sections of *Caunopora* the same vertical tubes can never be followed up through the whole mass, but they are mostly only a few lines in length.

[1] Das Rheinische Uebergangsgebirge, p. 5.
[2] Journ. Lin. Soc. vol. xiv. Zoology, pp. 211 and 219.
[3] *l.c.* p. 218, fig. 4.

This relation of *Aulopora* to *Stromatopora*, as may readily be seen in many Eifel specimens of *Stromatopora concentrica*, is not likely to be equally well observed in the specimens of *Caunopora* in the limestone of Devonshire, because these are inclosed in the compact limestone, and hardly ever show the surface well.

The structure of *Caunopora* is not confined to *Stromatopora concentrica*, but occurs likewise in the Silurian *Stromatopora striatella*. In the drift of North Germany rounded pieces of this latter species are frequently observed which are perforated by irregular vertical tubes in exactly the same manner as the masses of *Caunopora placenta* from Devonshire. Goldfuss[1] has figured a small and not very distinct specimen of this kind from the drift of Groningen in Holland under the name of *Syringopora filiformis*. Weathered and partly decomposed specimens of larger size from Sadewitz in Silesia have been described by myself[2] as *Heliolites interstincta*. They resemble in fact decomposed specimens of the latter species; but in sections which I made since, the *Caunopora*-like structure is very distinct. In a specimen from the drift at Groningen the horizontal network of *Aulopora*, and above it the vertical tubes of *Caunopora*, are very clearly seen in connexion. Certain specimens of *Stromatopora concentrica* from the Eifel offer instances of an animal (when covered by layers of the former) preventing itself from being suffocated by keeping up small holes through the mass of the *Stromatopora*. Among the many different forms of *Stromatopora*, those with large tubercles on the surface are frequent. Goldfuss has figured them in fig. 8*c*, 8*d*, 8*e*, and 8*f*, of plate lxiv. Each tubercle is usually perforated on the top by a small hole, or sometimes by several holes. Now in several specimens it could be ascertained that under every tubercle a specimen of *Spirorbis omphalodes*, the well-known little spiral Annelid, had its seat. The hole or the top of the tubercle is the opening of the canal by which that little animal kept up its communication with the surrounding water, and the tubercle was formed by the bending upwards of the successive layers of *Stromatopora* round this canal. In many cases the tubercles are not perforated on the top, evidently because at last the resistance of the Annelid had been overcome, and the opening closed by the later layers of the *Stromatopora*.

In conclusion: The facts which I desire to state in this note are:

1. *Caunopora* of Phillips is not a good genus, but is founded on masses of *Stromatopora* which are perforated by vertical tubes not essentially belonging to *Stromatopora*.

2. The tubes of *Caunopora placenta* are produced by stems of *Aulopora repens*, which, being covered by the concentric layers of *Stromatopora*, grow upwards in order to keep at least their calices open at the surface of the *Stromatopora* and prevent death from suffocation.

3. The Silurian *Stromatopora striatella* exhibits also occasionally the structure of *Caunopora*, and in this species likewise the vertical tubes are produced by a species of *Aulopora*.

[1] Petref. Germ. vol. i. p. 113, t. 38, fig. 15.

[2] Diluvial Geschiebe von Sadewitz, p. 24, t. 4, fig. 2*c*.

III.—On some Bones of the Lynx from Teesdale, obtained by Mr. James Backhouse of York.

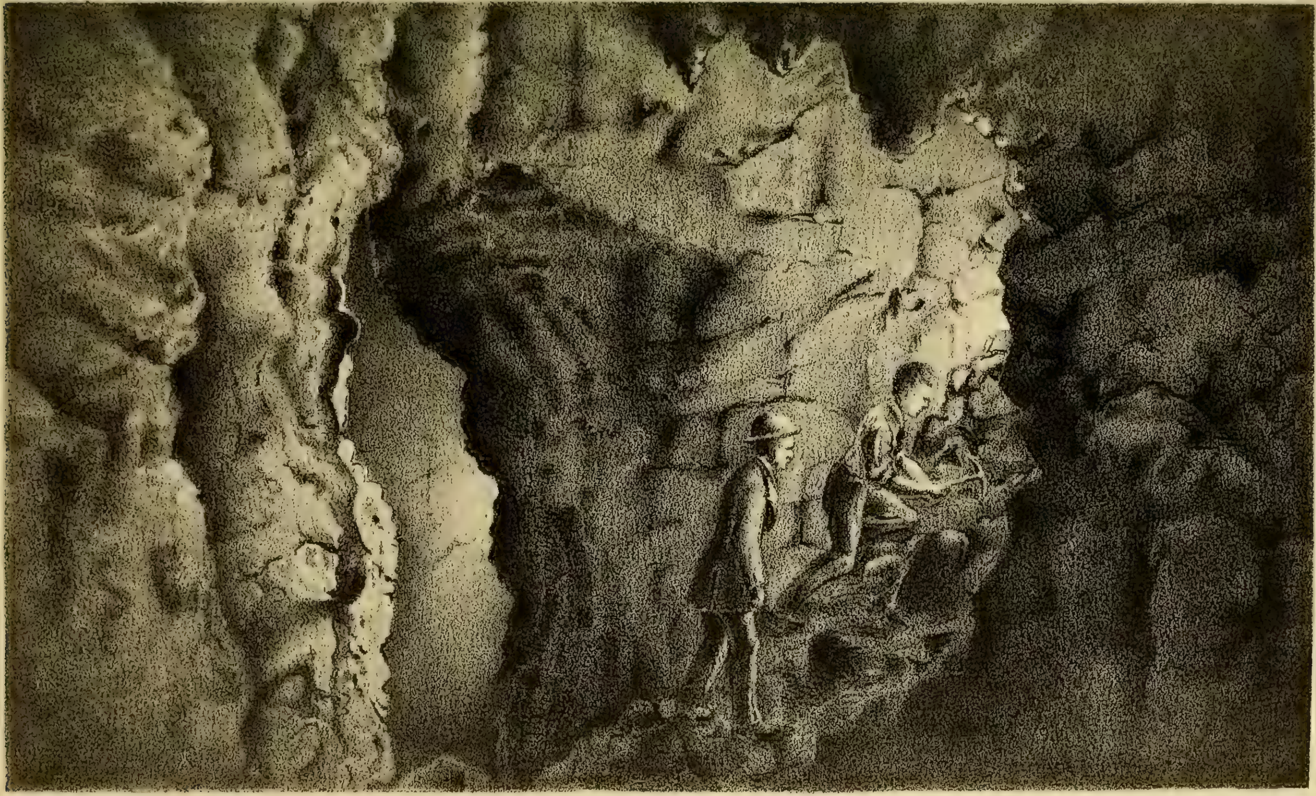
By William Davies, F.G.S.;
of the British Museum.

(PLATES XI. and XII.)

THE evidence relating to the habitation in England at some distant period of a species of the section of the genus *Felis* represented by the Lynx, rests, up to the present time, upon a portion of a skull and a ramus of a mandible, which were discovered in a cavernous fissure in rocks of Permian age, in Pleasley Vale, Derbyshire. They were found by Dr. Ransom, who communicated an interesting paper descriptive of the fissure and its contents, to the British Association Meeting held at Nottingham in 1866, and the fragments were then referred to the Lynx of Northern Asia (*Felis cervaria*). Subsequently they were examined by Professor Boyd Dawkins, who, after carefully comparing the skull, jaw, and teeth, with the corresponding parts of other species of Lynxes, and also taking into consideration its geographical range, says, "that they may be referred with equal justice to the Lynx of Norway and Sweden" (*Felis borealis*).[1]

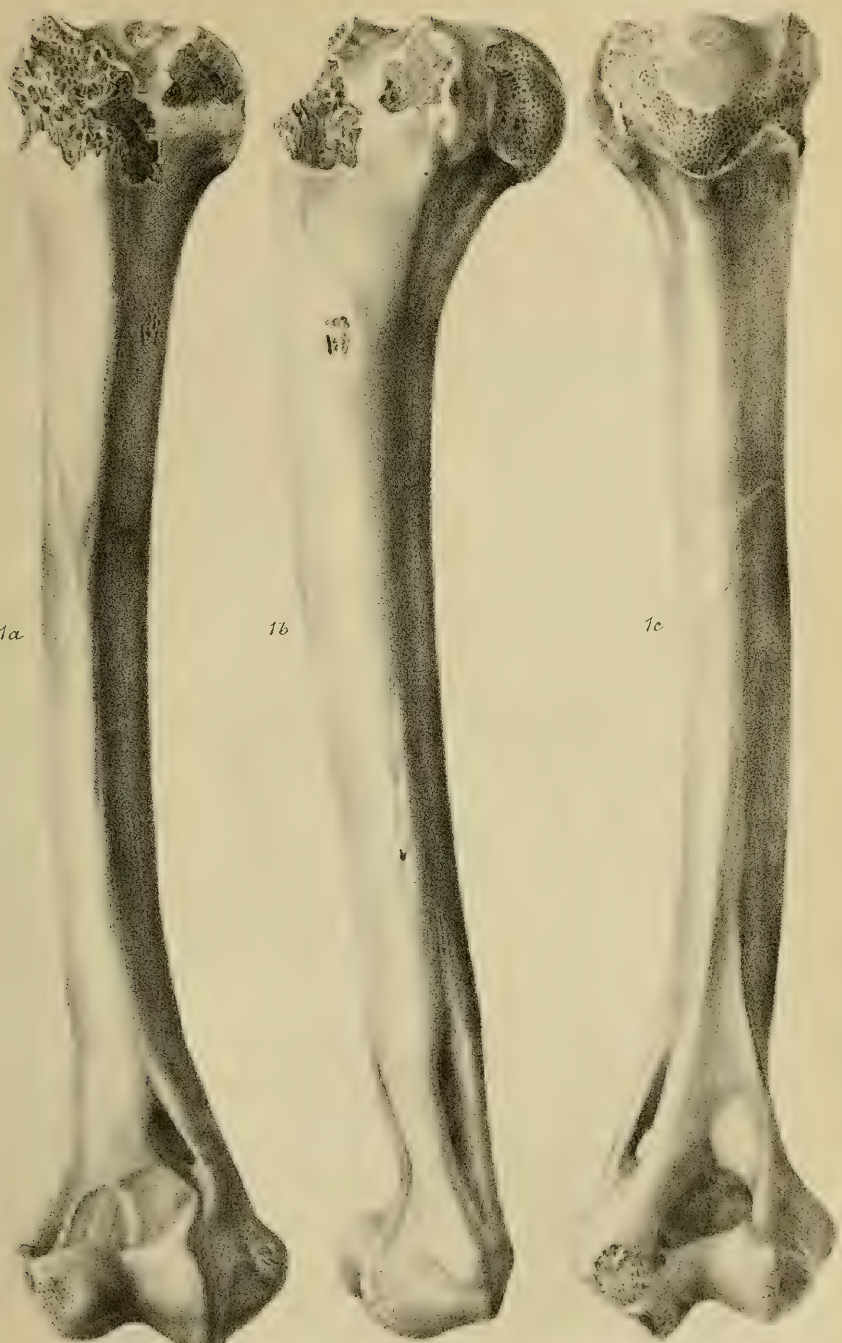
To the foregoing evidence may now be added two bones of the limbs, a humerus and a metatarsal, discovered under similar conditions, and associated with the debris of a similar fauna which had been deposited in a rock fissure in the Carboniferous Limestone in Teesdale, Durham. The specimens formed part of a very miscellaneous collection of bones sent to me for examination by James Backhouse, Esq., of York, who, in conjunction with his sons, Mr. James and Mr. W. E. Backhouse, discovered and explored the "cave," and themselves, with the assistance of a miner, extracted the various objects found therein. These consist of remains of many kinds of animals, but all of species now existing, and, eliminating a few forms, probably still native to the district. The bones of the Lynx are in excellent preservation, and were it not for some slight abrasions of the margin of the scapular articulation, and of the great trochanter, the humerus might be pronounced perfect. It belonged to an adult animal, somewhat smaller than the Northern Lynx, as represented by a skeleton of a large individual from Sweden (British Museum Collection, 1230*a*), with which I compared it. The annexed measurements of the recent and fossil bones will show their relative proportions, and general correspondence. In the fossil the space posterior to the ridge which descends from the lesser trochanter, and to which is attached the first head of the anconeus medius muscle, is more deeply depressed, otherwise the two bones are so alike that there can be little doubt as to their specific identity. Of *Felis cervaria* there is no skeleton in the National Collection, so that I have been unable to learn by comparison whether it possesses characters by which it could be differentiated from its northern relative.

[1] Monographs of the Palæontographical Society, 1868, Pleistocene Mammalia, part iii. p. 174.



G.M. Woodward lith. (J. Backhouse del.) West, Newman & Co. imp

The spot where the bones of the Wolf & the Lynx were found; Teesdale Cave.



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

Humerus of Lynx from Teesdale.

The metatarsal is the third of the right foot; it is also perfect, and, as it bears the same relative proportion to the humerus, as do the same bones to each other in the recent skeleton above referred to, the fossils may safely be assigned to the same animal.

The following measurements of the fossil and recent bones, show that the present Lynxes are not dwarfed descendants of their early predecessors. The measurements are in inches and tenths.

MEASUREMENTS OF HUMERUS.	FOSSIL.	RECENT.
Maximum length	7′ 12	7′ 6
Transverse diameter proximal articular end	1′ 2	1′ 3
Antero-posterior diameter of scapular articulation	1′ 05	1′ 15
Transverse diameter of distal end	1′ 4	1′ 5
Ditto ditto of trochlea	0′ 87	1′ 0
Antero-posterior diameter of ulnar articulation	0′ 65	0′ 75
Smallest circumference of shaft	1′ 75	1′ 75
MEASUREMENTS OF METATARSAL.		
Length	3′ 8	4′ 07
Transverse diameter proximal end	0′ 45	0′ 55
Ditto ditto distal end	0′ 48	0′ 52

So far as they have been specifically identified, the associated vertebrate remains occurring, both in the Pleasley Vale and in the Teesdale Cave, are the same. In neither have been found any bone of the extinct Pleistocene Mammals, nor of the cave Hyæna or Bear. From the former cave, Dr. Ransom enumerates the Wolf, Fox, Pig, Roebuck, Water Vole, and a large number of bones that he had "not yet determined." From the Teesdale Cave have been obtained bones of the Shrew, Mole, Wolf, Dog, Fox, Wild Cat, Lynx, Marten, Otter, Badger, Horse, Ass (?), Wild Boar, Red Deer, Roebuck, Goat or Sheep, small Ox, Hare, Rabbit, and water, bank, and field Voles; also bones of Birds; Snakes or Lizard, and Frogs. A good total, but all of which, Mr. Backhouse assures me, were exhumed from the "Cave." However, many of the bones, judging, from their state of preservation, have been introduced into the cave in comparatively recent times; among which may be specially mentioned the domestic Cat, Dog, Rabbit, Sheep or Goat, the small Ox (*Bos longifrons ?*), and a few others. Nevertheless, many are of early introduction, and were undoubtedly contemporary with the Lynx; and, although belonging to species dating from Pleistocene times, were yet still common in Britain in the historic period; for the Wolf and Wild Boar roamed at will over the northern counties within a few centuries ago, and the Fox, Badger, and Otter, and other forms of equally ancient origin, are still native.

These facts have an interesting bearing in regard to the geological age of the respective caves, and of the presence in time of the Lynx in Britain. Neither cave has yielded evidence by which it could be connected with certainty to any period. Prof. Boyd Dawkins, commenting upon this subject, in reference to the antiquity of the various remains found in the Derbyshire Cave, and which comments apply with equal force to those from Teesdale, says: "So far as the internal evidence goes, they may be of Pre-historic, or even Historic date, with as great probability as Postglacial." He, however, thinks "the latter hypothesis the most tenable," because bones of the tichorhine Rhinoceros, Mammoth and Bison have been found in a cave in the neighbourhood; also, that "the carnivore in question must have crossed over into Derbyshire while Britain formed part of the mainland of Europe." From these circumstances he concludes that "its Post-glacial age, therefore, may be assumed with a very high degree of probability, although not with absolute certainty."[1] Although concurring with these views, I must remark that no bones of extinct Pleistocene Mammals have been found in or about Teesdale; and the question naturally arises, if the animal under consideration was contemporary with its congeners the Cave Lion and Wild Cat, and was as generally distributed in area and in time, as we may assume it would be, in Britain, how is it that its remains are so rare, and in each instance derived from caves in which they are associated with bones of animals whose date of deposit cannot be satisfactorily assigned to any one of the three periods named? Its haunts and general habits are much alike to those of the Wild Cat; and while the bones of the latter, and also of the Lion, are far from rare, and are disseminated in many localities, not only in caves, but also in Pleistocene aqueous deposits (those of the Lion always, and of the Cat frequently, being associated with the remains of extinct species of Mammalia), no bone of the Lynx has been found under similar conditions; it must, therefore, be admitted that the period when the Lynx prowled in Britain is still a moot question.

The subjoined note has been forwarded to me by Mr. James Backhouse, and is inserted together with a view of the interior of the cave near the spot where the bones of the Lynx were found. (Plate XII.)

[The "Cave," above referred to by my friend Mr. Davies, is situated on the ridge of hills separating Weardale from Teesdale, and is at an elevation of about 1600 feet above the sea, and 500 feet or more above the adjacent valley of the Tees.

It consists of a series of nearly parallel fissures, varying in width from 1½ to 4 feet, intersected by transverse ones at right-angles with the main lines. These fissures are, in some places, 20 to 30 feet high, the "roofs" being gothic, and the lower portions tapering downwards. In a few places, where the width is greatest, the roof is "flat."

Stalagmitic deposits beautifully incrust the sides in many parts, and here and there form the floor of the galleries. In a few places only stalactites occur.

The plateau of Carboniferous Limestone above the cave covers many acres. Up to the present time we have only penetrated about 250 feet, but it is probable that the rock is fissured more or less throughout its entire area, and that considerable advance may yet be made.

Connected with the main cavern, but by a fissure so narrow as to be impassable, is a smaller one, traditionally known as "The Fairies' Hole." This we opened out, and explored first; and bones were

[1] *op. cit.* p. 173.

found in both. The opening into the larger cave was originally a mere crevice four to six inches wide, requiring many tons of cliff to be removed ere we could effect an entrance. Even then, for some 20 feet, it was but a natural "tunnel," too small, in most parts, either to creep or turn in. No large animals could possibly have entered *there;* so that the presence of their bones beyond, more or less imbedded in stalagmite, proved that some other entrance, not yet detected, must once have existed.

From one of the ramifications, we extracted almost the entire skeleton of a Wolf. Its bones were intermingled with those of a Roebuck, on which it had probably been feeding. The Wolf's skull was a little over three-fourths the size of a full-grown male Arctic specimen. A single canine tooth, belonging to a much larger Wolf, was found at no great distance, and near to the place where the Lynx bones were imbedded.

I see no reason to doubt that the Lynx may have roamed throughout our forests and mountain glens, along with the Wolf and the Bear, till a comparatively recent period, just as it still does in Norway; albeit its origin in Great Britain probably dated from the time when these islands were united to the Continent. James Backhouse.]

EXPLANATION OF PLATES XI. and XII.

Plate XI. Figs. 1*a*, 1*b*, and 1*c*. Three views of the humerus of the Lynx (*Felis borealis*) from Teesdale.

1*a*. Front view.
1*b*. Outer side-view.
1*c*. Back view.

Plate XII. View of the interior of the cave where the bones of the Lynx and the skeleton of the Wolf were found. From a sketch made on the spot by Mr. Backhouse.

IV.—Influence of Earth Movements on the Geological Structure of the British Isles.[1]

By J. J. Harris Teall, M.A., F.G.S.,
Late Fellow of St. John's College, Cambridge.

IN the formation of a country three more or less distinct geological operations are concerned:—*a*. Rock formation; *b*. Earth movements; *c*. Denudation. In the case of our own country, to which the present paper more especially refers, these three operations have succeeded each other again and again; so that a very complicated structure is the result. The earth movements and denudations of one period have been interfered with by those of subsequent periods, and any attempt to trace the exact steps by which the evolution of the British Isles has been effected is therefore attended with very great difficulty. Earth movements may be divided into three groups, as follows:—

a. Slow movements of elevation and depression analogous to those now going on in the Scandinavian peninsula.

b. Movements which result in the displacement of rocks along planes usually inclined at a high angle to the horizontal surface; these are more familiarly known as faults.

[1] This article contains the substance of a paper read before the Literary and Philosophical Society, Nottingham.

c. Movements due to lateral pressure which produce a folding or contortion of the stratified rocks along certain definite lines.

It must be understood that this classification is proposed merely for the purpose of aiding description, and not because I believe that these three classes of movements are radically distinct. I have little doubt that they are very closely connected and that the nature of this connexion will at some future time be fully established. In the present communication I propose to refer to those movements of the third class which have affected the stratified rocks of Great Britain and Ireland, to discuss their geological age, and to describe the effects they have produced on the actual structure of our country. I have nothing new in the shape of facts to offer; my object is merely to collect together the knowledge which various workers in the field of geology have accumulated with reference to this interesting topic, and in conclusion to suggest an extension of what may be fairly called the American theory of the origin of mountains to the subject in question.

The earliest earth movement of which we have direct evidence is one which affected the Pre-Cambrian rocks of the N.W. of Scotland and S.W. of Wales. In the former locality these rocks consist of highly crystalline gneiss, with occasional beds of limestone and ironstone, evidently the metamorphosed representatives of marine formations. They are now arranged in strata dipping towards the N.E. and S.W., in such a way as to show that subsequent to their formation, and probably during the time when the metamorphism was produced, they were subjected to forces which contorted the rocks along axes running N.W. and S.E. In the S.W. of Wales, in Pembrokeshire, rocks similarly related to the Cambrian occur. These have been divided by Dr. Hicks into two groups,[1] to the earlier of which he gives the name Dimetian, and to the later Pebidean.

The lower, or Dimetian series consists of compact quartziferous beds and altered shales and limestones, which strike in a N.W. and S.E. direction, thus showing, in all probability, that they were affected by the same earth movements as the homotaxial beds of the N.W. of Scotland and the Hebrides. The upper or Pebidean series consists of altered conglomerates and shales, the pebbles of the conglomerate having been derived from the earlier formation. These beds are entirely unconformable to the Dimetian series, and strike in a direction W.S.W. and E.N.E. The same old Pre-Cambrian rocks as those to which Dr. Hicks has given the term Dimetian in all probability again come to the surface in the Malvern Hills, where they consist of regularly stratified gneiss, having the usual strike.

If the newer formations which cover the country at all those points intermediate between the localities above mentioned could be removed, we should find in all probability that these early Pre-Cambrian rocks are very widely distributed, even at present. During the Cambrian period they formed the superficial crust of the earth,

[1] Dr. Hicks now divides the Pre-Cambrian rocks into three groups, Dimetian, Arvonian, and Pebidean.

and on them, as on a floor, the Cambrian rocks were formed. Dr. Hicks believes that a large continent, formed principally of these rocks, existed very much in the position now occupied by Europe, and that the Cambrian deposits were formed on the borders of this continent as it gradually became submerged. The submergence, he supposes, commenced in the West, where the Cambrian rocks are thickest, and gradually extended eastwards. If, however, we hold with Dr. Hicks that these Pre-Cambrian rocks were originally distributed over the whole of the British Isles, and formed the floor on which the later deposits were formed, we must not suppose that at present they would be found at all points, if the later deposits were removed. Owing to the depression which accompanied the deposition of many of the later deposits, such as the Cambrian, the early Pre-Cambrian floor must have been buried sufficiently deep in the earth's crust to have been completely fused.

We conclude, then, from the arrangement of these early rocks, that the first earth movements of which we have direct evidence took place along axes running N.W. and S.E., and that they were probably due to lateral pressure acting from N.E. and S.W.

Passing over, for the present, the evidence of additional Pre-Cambrian earth movements furnished by the Pebidean rocks of Hicks, we come to the Cambrian rocks proper. And here it must be understood that I use the term Cambrian to include the entire series of deposits intervening between the Longmynd, Harlech and Llanberis group, and the Llandovery beds. Whatever may be our views as to the propriety of abolishing the term Lower Silurian from geological nomenclature, there cannot be a shadow of a doubt that for our present purpose the rocks indicated above must be treated as forming one great natural group. They have all been affected by the same earth movements.

The total maximum thickness of the Cambrian series, according to Woodward, is about 30,000 ft. in Wales, and 20,000 ft. in the Lake District. In the Highlands of Scotland[1] it is quite impossible to form an estimate of the total thickness, on account of the difficulty of determining particular horizons. Now since the basement beds of the Cambrian consist of deposits that were certainly formed in shallow water, if not in inland seas or lakes, we must suppose that during the Cambrian period there was depression at least to the extent of the thickness of the deposit, that is, to the extent of 30,000 ft. To this depth in the crust of the earth must the original surface, composed as we have seen of Dimetian and Pebidean formations, have been carried.

The Cambrian rocks are now found to be arranged in anticlinal and synclinal folds, running N.E. and S.W., showing that at the close of the Cambrian period, and, as we shall see in a moment or two, before the Silurian period, they must have been puckered up by lateral pressure acting from the N.W. and S.E. over the whole of our area.

This anticlinal and synclinal arrangement of rocks is well seen on

[1] Are these rocks Cambrian or Pre-Cambrian?

a large scale in North Wales, where, if we leave out of account certain smaller undulations, and neglect the effect of faults, we may describe the rocks as arranged in two great synclinal folds, separated by an anticlinal fold. Thus, beginning in the N.W., we have first of all the great synclinal roll, along the axis of which lie the mountains Moel Hebog, Snowdon, and Glyder Fawr; then, following this, the Merionethshire anticlinal (see Memoirs of the Geological Survey, vol. iii.); and following this again the Berwyn synclinal. It is worthy of note that the anticlinal axis of Merionethshire is not horizontal, but slightly inclined to the N.E., so that the mountains of Cader Idris, the Arans, and the Arenigs, which are all formed by the outcrop of the harder igneous rocks of Llandeilo age, do not trend in a N.E. and S.W. direction, but bend round towards the N., following of course the strike of the beds. The same igneous beds about Ffestiniog run in a N.E. and S.W. direction. The effect of the earth movements here referred to may be traced over the whole of the area now occupied by Cambrian formations, the strike of the beds in all districts varying little from a N.E. and S.W. direction. Where igneous rocks are intercalated with the sedimentary deposits, the prevalent strike may be observed at once by a glance at the geological map, as in N. Wales, S.W. Wales, and the S.E. of Ireland. In other districts, though not indicated by any feature on the maps, it may readily be detected in the field. There can be little doubt that the Cambrian strata were formed over all the area now occupied by the British Isles, and that the earth movements which have affected the Cambrian rocks extended also over the whole of the district. To these earth movements then we are indebted for the present physical structure, and, to a certain extent, though only indirectly, for the scenery also of our mountainous regions. With regard to the age of these disturbances, I have already stated that they took place before the Silurian period. This is borne out by the fact that in Wales the Silurian rocks rest unconformably on the Cambrian, and do not seem to have been affected by the movements which produced the anticlinal and synclinal folds so marked in the Cambrian regions. Cleavage, moreover, is for the most part absent in Silurian formations. There is, however, some little difficulty here, for the Denbighshire grits appear to have been affected by movements which have also affected the Cambrian, and in the Lake District a similar condition of things has been observed. In all probability these facts are to be explained by a second series of earth movements, of Post-Silurian date, which affected the already disturbed Cambrian rocks, and also the comparatively undisturbed Silurian rocks. One bit of evidence of great importance in determining the date of the earth movements we are considering, and the metamorphism which seems to have accompanied them in the region now occupied by the Highlands of Scotland and the North Western Highlands of Ireland, is to be found on the shores of Killery Harbour, and in the Eriff Valley on the borders of Counties Galway and Mayo (see Geology and Physical Geography of Ireland, by Prof. Hull). Here Silurian rocks of the Llandovery age rest unconformably on the denuded edges of the old metamorphic rocks, and consist at the base of a conglomerate containing pebbles of the older Cambrian formation. If then, as is extremely probable, the N.W. and S.E. strike of the Cambrian rocks of all localities was produced by one series of earth movements, due probably to lateral pressure acting from the N.W. and S.E., then this observation at Killery Harbour serves to fix the date of these earth movements in every locality.

During the time which elapsed between the commencement of the Silurian and the close of the Carboniferous, the British Islands do not seem to have been subjected to any forces giving rise to anticlinal and synclinal folds on a large scale. Various earth movements must have taken place, but these seem to have been gradual movements of elevation and depression, rather than movements due to lateral pressure. During the deposition of the Silurian, Old Red Sandstone, Devonian and Carboniferous rocks, depression must have taken place. The depression, however, was not a continuous one, for in Scotland there are at least two distinct unconformabilities, one between the Middle and Lower Old Red Sandstone, the other between the Upper and Middle. In Herefordshire and Shropshire, and the adjoining counties, no unconformability has been detected in the Old Red Sandstone, though one is strongly suspected. In Ireland there is a marked unconformability between the Old Red Sandstone and Dingle beds, and in all probability another of less importance between these latter and the Silurian. In addition to the movements of elevation indicated by the unconformability, there must have been others, the only evidence for which is to be found in the change of character in successive deposits. Thus the Old Red Sandstone rocks, which succeed the Silurian conformably, were formed, in all probability, in a land-locked area, while the latter were certainly laid down in the open ocean. In order that a given spot may at one time be situated in the open ocean, and at another in a land-locked basin, it is necessary that elevation of some sort should take place in the adjoining area.

The movements of this period were not, however, of such a character as to influence in any marked way the physical structure of the country, and therefore, although they have an importance of their own, which it is impossible to overestimate, we may leave them without further notice.

The next great series of earth movements of the character we are more especially considering took place at the close of the Carboniferous period; like the previous earth movements of a similar character, they seem to have exerted an influence over the whole of the area occupied by Carboniferous formations. They may, however, be best studied in the district of Lancashire, Derbyshire, and Yorkshire, where facts may be observed which enable us to determine their geological ages. In the Q J.G.S. vol. xxiv. p. 323, there is an able paper by Prof. Hull on the relative ages of the leading physical features and lines of elevation of the Carboniferous district of Lancashire and Yorkshire. In this paper the author discusses the ages of two great series of earth movements which have affected the Carboniferous rocks. With regard to the first of these he points out that the Permian rocks, consisting of red sandstones and magnesian limestones, rest on the denuded edges of the Millstone-grit near the south-western termination of the Pendle Range; thus proving beyond a doubt that the disturbances to which the anticlinal and synclinal axes of the Pendle District are due took place before the Permian period. He further points out that even in the absence of such direct evidence as that which is furnished by the superposition of Permian rocks on Lower Carboniferous deposits, we could still infer with certainty the Pre-Permian date of the movements in question; for the uprising of Millstone-grit and Yoredale rocks on the northern side of the Yorkshire Coal-basin is undoubtedly due to an extension of the movements which produced the anticlinal and synclinal of the Lancashire District towards the east. The Permian rocks, however, consisting of red sandstones, marls, and magnesian limestones, have not been affected by these movements, for, as may be seen by a glance at the geological map, they rest unconformably on the edges of the Carboniferous rocks striking N. and S., whereas these latter strike nearly E. and W. There cannot then be a shadow of a doubt that the E. and W. axes of Lancashire belong to the period intervening between the Carboniferous and Permian. The geological map shows also that many other districts have been affected by movements along E. and W. axes; and, since parallelism is to a certain extent evidence of contemporaneity, many of these probably belong to the same period of disturbances. Thus in S. Wales we notice the E. and W. strike of the Carboniferous rocks. In the Mendips the axis runs E. and W., and, again, over the whole of Devon and Cornwall, we notice a prevailing E. and W. strike. Tracing the Devonian and Carboniferous rocks towards the east, we find that they disappear under the Mesozoic formations which rest upon them unconformably; still we have reason to believe that the E. and W. strike is continued; for, at a depth of a thousand feet under London, Devonian rocks have recently been obtained, and in France, in the Ardennes, they again emerge from beneath the Secondary formations. Passing west instead of east, from the district of Devon and Cornwall, we find in the South of Ireland rocks which represent the Carboniferous, Old Red Sandstone, and possibly the Devonian formations striking E. and W., or rather slightly S. of E. and N. of W. In the district of Killarney the arrangement of the rocks in question has been carefully observed, and is well represented in the Survey Section drawn N. and S. From these facts then we conclude that the district over which Carboniferous rocks had accumulated to such a great extent was at the close of that period subjected to lateral pressure from the N. and S., or from N.N.W. and S.S.E., and that as a consequence of this pressure the surface of our country became puckered up along lines running E.N.E. and W.S.W. It was during this period that the Pendle Hills of Lancashire, the Mendip Hills of Somersetshire, the Mountains of Kerry, and in all probability the Carmarthenshire Vans became stretched out.

We have now to consider another series of earth movements, about the age of which there is some difference of opinion. I refer to the N. and S. movements that have affected Carboniferous rocks, and of which the Pennine Anticlinal may be taken as a type. In the paper above quoted Prof. Hull discusses their age, and arrives at the conclusion that it was Post-Permian and Pre-Triassic. Now for a long time, ever since I became acquainted with Nottingham in fact, I have been of opinion that Prof. Hull is wrong on this point. I propose briefly to discuss the evidence which Prof. Hull offers in support of his view, and then to call attention to facts which convince me that he is wrong. To Mr. Wilson belongs the credit of first pointing out the error in the date of these N. and S. movements (see Q.J.G.S. vol. 1876, page 76). The axis of the Pennine Chain is marked by a fault, which Prof. Hull calls the "Anticlinal Fault," on account of the strata dipping away from it on either side; this fault may be traced for a distance of fifty miles or more in a N. and S. direction, from Colne to Leek. Near this latter place it passes beneath Triassic rocks without fracturing them, thus proving that it was Pre-Triassic. Running parallel with this fault are several others in all probability of the same age; one of these, the so-called Red Rock Fault, forms the boundary between the Coal-measures and the later formations from Bredbury and Poynton southward for several miles. At one point this fault affects the Permian sandstones, and thus is proved to be Post-Permian. From this Prof. Hull concludes that the Pennine Anticlinal was first stretched out in Post-Permian and Pre-Triassic times. Prof. Hull next proceeds to consider an objection to the Pre-Triassic age of the Red Rock Fault. Near Macclesfield and Congleton this fault affects Triassic rocks, thus apparently showing that the fault is of later date than the Triassic formation. This objection is answered by the supposition that there were two series of earth movements along the same lines, one before the Triassic rocks were formed, and another after, and certainly nothing can be more probable than this, especially when we remember that at a point near Leek the anticlinal fault passes under but does not dislocate Triassic rocks. That is the evidence on which the Post-Permian and Pre-Triassic date of the Pennine axis is based. Now there is one consideration which to my mind completely destroys the value of the evidence; in order to explain the facts observed with reference to the Red Rock and Anticlinal Faults, two series of movements along the same lines have to be assumed; but if two movements took place, why not three? And why may not the first of these have been Pre-Permian? *The evidence is not conclusive until it can be shown that N. and S. movements did not take place until after the Permian period, and no attempt is made to prove this.*

From a discussion of the evidence as advanced in the above-mentioned paper, let us pass to the consideration of some additional facts which prove, beyond the shadow of a doubt, that north and south movements did affect the Carboniferous rocks before Permian times. The eastern side of the exposed portion of the Nottinghamshire and Yorkshire Coal-basin is bounded by the Magnesian Limestone (Permian) formation which rests *unconformably* upon the Carboniferous rocks along the whole line. Moreover, the strike of the Carboniferous rocks beneath the Permian formations is the same as that in the exposed portion of the Coal-field, that is, approximately N. and S. These relations are admirably exhibited in the neighbourhood of Nottingham, and they are well known to be true of regions north of Nottingham by all mining engineers and others who have specially studied the structure of the district. Now the N. and S. strike of the Carboniferous rocks both on the east and west side of the Pennine axis must have been determined by N. and S. movements; and since this strike is continued beneath the Permian formations, it is clear that the cause which determined it must have acted before that period. I have no hesitation, then, in asserting that Mr. Wilson is right when he says, that "the lapse of time which is represented by the unconformability between the Carboniferous and Permian was accompanied by the elevation and folding of the strata, not only along east and west (*e.g.* Pendle and Cheshire anticlinals), but also north and south (*e.g.* Pennine) axes, and by the sketching out of the great Coal-basins by denudation." To sum up, we find that at the close of the Carboniferous and before the Permian period two great series of earth movements affected Carboniferous strata, the one series acting nearly in an E. and W. direction, the other nearly N. and S.; which was the earlier series I do not know. The intersection of the axes due to these two series of movements has evidently given rise to the basin-shaped form of our Coal-fields, in the manner so admirably pointed out by Professor Hull. From the Permian to the close of the Eocene we have an immense period of time, during which no movements of the kind I am now speaking about appear to have taken place in our area. Numerous elevations and depressions undoubtedly occurred, but nothing like the puckering and crumpling of a great thickness of stratified deposit. Some time after the close of the Eocene period, however, we find that the South of England was subjected to forces which rolled the Cretaceous and Eocene rocks along axes running E. and W. and gave rise to the anticlinal arrangement of the rocks in the Wealden district as well as the nearly vertical position of homotaxial deposits in the Isles of Wight and Purbeck. These movements have an interest for us even greater than their magnitude would indicate, for they appear to have been contemporaneous with the breaking up of the vast geosynclinal in Central Europe which resulted in the formation of the Alpine system of mountains; they are the ripples, so to speak, which have extended from this great centre of disturbance.

We have now considered the various movements which have resulted in the crumpling, contortion and metamorphosis of our British stratified deposits. They may be classified as follows:

(1) Pre-Cambrian	N.W. and S.E.
(2) Pre-Silurian	N.E. and S.W.
(3) Pre-Permian	*a.* E.N.E. and W.S.W.
	b. N. and S.
(4) Pre-Pliocene	E. and W.

The interest attaching to this paper will be very considerably increased if we view the facts here recapitulated in connexion with the theory of mountain-making first enunciated by Hall, and subsequently elaborated by the American geologists Dana, Sterry Hunt, Le Conte and others. The theory referred to may be briefly stated as follows. In the formation of a mountain mass the first important operation of which we have any evidence is the accumulation of a vast thickness of sedimentary deposits accompanied by a slow subsidence of the earth's crust. At a certain point, owing to the weakening of the floor on which the sedimentary deposits were first thrown down, the lateral pressure due to the secular cooling of the earth operates upon the sedimentary mass, which thereby becomes "folded, profoundly broken, shoved along, fractured and pressed into a narrow space" (Dana, Manual of Geology, page 749). To the downward bending of the earth's crust Professor Dana has applied the term *Geosynclinal*, and to the mountain mass which results from the breaking up of the sedimentary deposits formed in a geosynclinal he has applied the term *synclinorium.* The theory here sketched out appears to be applicable to all great mountain ranges. I would extend it still further, however, and use it to account for all the great systems of folds which are revealed by a study of the structure of the earth's crust, whether these systems occur in mountain ranges or not. Thus it seems to me that the four great systems of earth movements referred to in the present paper are strictly in accordance with this theory. The metamorphosed Pre-Cambrian rocks of N.W. of Scotland, the S.W. of Wales and Malvern, represent, it is believed, a great accumulation of sedimentary material; the geosynclinal which accompanied the formation of this material was broken up before the Cambrian period, and in this breaking up the rocks were folded and metamorphosed, and the existing strike determined. The lateral pressure acted, as we have seen, from the N.E. and S.W., and therefore, according to our theory, the original sedimentation should have been greatest along N.W. and S.E. lines. The second great period of sedimentation was the Cambrian of Sedgwick, this was broken up in Pre-Silurian (Sedgwick) times by pressure from N.W. and S.E. The maximum sedimentation in this case should have been in a N.E. and S.W. direction. The third great period of sedimentation was brought to a close by the formation of our Coal-measures, and this was followed as before by folding and contortion. Here, however, we cannot say that the folds follow any *one* course or direction; two parallel courses appear to be indicated. The earth movements in the Tertiary period followed on sedimentation, which reached its maximum in Central Europe, and which culminated in the formation of the Alpine range.

V.—Aqueous Vapour in Relation to Perpetual Snow.

By James Croll, LL.D., F.R.S.

SOME twelve years ago I gave (Phil. Mag. March, 1867, "Climate and Time," p. 548) what appears to me to be the true explanation of that apparently paradoxical fact observed by Mr. Glaisher, that the difference of reading between a thermometer exposed to direct sunshine and one shaded *diminishes* instead of increases as we ascend in the atmosphere. This led me to an important conclusion in regard to the influence of aqueous vapour on the melting-point ot snow; but recent objections to some of my views convince me that I have not given to that conclusion the prominence it deserves. I shall now state in a few words the conclusion to which I refer.

The reason why snow at great elevations does not melt, but remains permanent, is owing to the fact that the heat received from the sun is thrown off into stellar space so rapidly by radiation and reflection that the sun fails to raise the temperature of the snow to the melting point: the snow evaporates, but it does not melt. The summits of the Himalayas, for example, must receive more than ten times the amount of heat necessary to melt all the snow that falls on them, notwithstanding which, the snow is not melted. And in spite of the strength of the sun and the dryness of the air at those altitudes, evaporation is insufficient to remove the snow. At low elevations, where the snow-fall is probably greater, and the amount of heat received even less than at the summits, the snow melts and disappears. This, I believe, we must attribute to the influence of aqueous vapour. At high elevations the air is dry, and allows the heat radiated from the snow to pass into space; but at low elevations a very considerable amount of the heat radiated from the snow is absorbed by the aqueous vapour which it encounters in passing through the atmosphere. A considerable portion of the heat thus absorbed by the vapour is radiated back on the snow; but the heat thus radiated being of the same quality as that which the snow itself radiates is on this account absorbed by the snow. Little or none of it is reflected like that received from the sun. The consequence is that the heat thus absorbed accumulates in the snow till melting takes place. Were the amount of aqueous vapour possessed by the atmosphere sufficiently diminished, perpetual snow would cover our globe down to the sea-shore. It is true that the air is warmer at the lower than at the higher levels, and by contact with the snow must tend to melt it more at the former than at the latter position. But we must remember that the air is warmer mainly in consequence of the influence of aqueous vapour, and that were the quantity of vapour reduced to the amount in question, the difference of temperature at the two positions would not be great.

But it may be urged as a further objection to the foregoing conclusion, that, as a matter of fact, on great mountain chains the snow-line reaches to a lower level on the side where the air is moist than on the opposite side where it is dry and arid. As, for example, on the southern side of the Himalayas, and on the eastern side of the Andes, where the snow-line descends some 2000 or 3000 feet below that of the opposite or dry side. But this is owing to the fact that it is on the moist side that by far the greatest amount of snow is precipitated. The moist winds of the S.W. monsoon deposit their snow almost wholly on the southern side of the Himalayas, and the S.E. trades on the east side of the Andes. Were the conditions in every respect the same on both sides of these mountain ranges, with the exception only that the air on one side was perfectly dry, allowing radiation from the snow to pass without interruption into stellar space, while on the other side the air was moist, and full of aqueous vapour, absorbing the heat radiated from the snow, the snow-line would in this case undoubtedly descend to a lower level on the dry than on the moist side. No doubt more snow would be evaporated off the dry than off the moist side, but melting would certainly take place at a greater elevation on the moist than on the dry side, and this is what would mainly determine the position of the snow-line.

In like manner the dryness of the air will in a great measure account for the present accumulation of snow and ice on Greenland and on the Antarctic continent. I have shown on former occasions that those regions are completely covered with permanent snow and ice, not because the quantity of snow falling on them is great, but because the quantity melted is small. And the reason why the snow does not melt is not because the amount of heat received during the year is not equivalent to the work of melting the ice, but mainly because of the dryness of the air, the snow is prevented from rising to the melting point.

There is little doubt but that the cold of the glacial epoch would produce an analogous effect on temperate regions to that experienced at present on Arctic and Antarctic regions. The cold, although it might to some extent diminish the snow-fall, would dry the air and prevent the temperature of the snow rising to the melting point. It would not prevent evaporation taking place over the ocean by the sun's heat but the reverse, but it would prevent the melting of the snow on the land during the greater part of the year.

In places like Fuego and South Georgia, where the snow-fall is considerable, perennial snow and ice are produced by diametrically opposite means, as I have elsewhere shown, viz. by the sun's heat being cut off by clouds and dense fogs. In the first place the upper surface of the clouds act as reflectors throwing back the sun's rays into stellar space, and in the second place, of the heat which the clouds and fogs absorb, more than one-half is not radiated downwards on the snow, but upwards into space. And the comparatively small portion of the heat which manages to reach the ground and be available in melting the snow is insufficient to clear off the winter's accumulation.

VI.—Upper Devonian in Devonshire.[1]

By A. Champernowne, M.A., F.G.S.

HAVING read Mr. Reid's letter on the above subject in the Geological Magazine for June, referring to the Chudleigh district, I beg to offer you a few lines of my own, in hopes of clearing up some confusion that may exist on the subject.

In the first place, I cannot admit what Mr. Reid appears to imply, viz. that there are two Cephalopodous horizons in this small quarry (of Lower Dunscombe), a *Clymenia* limestone and a *Goniatites intumescens* stage. On the contrary, there is a passage from the upper-

[1] Received too late for insertion in the July Number.—Edit. Geol. Mag.

most five or six feet of thin-bedded red limestone with light clay partings down into the thicker-bedded limestone of the rest of the quarry, and consequently Mr. Reid may well have found Cephalopoda in some of the uppermost of the latter, but the Cephalopod fauna as a whole, including *Orthoceras* (2 sp. at least) and *Cyrtoceras* sp., is clearly confined to the uppermost beds.

In the rest of the quarry I have found two examples of either *Rhynch. pugnus* or *Rh. acuminata* var. *mesogonia*, of the average size of those which have turned up at Woolborough quarry, large Crinoidal stems, and a few Corals.

The limestone dips about W. 30° S. at 20° with an undulation, away from a fault which throws a mass of Culm-measures against them on the east with a northerly dip. In an old roadway between Lower and Higher Dunscombe, the edges of grits and shales are seen for some distance steadily dipping into the hill. In the road leading from Chudleigh to Beggars Bush, about a furlong from the turning to Waddon Barton, Culm-shales and thin grits strike with the road and pitch N. 5° W. steeply (mean 45°). In the road from Lower Dunscombe to Chudleigh, under the 'e' of the word 'Biddlecombe" on the map, Culm-shales dip E. 27° S. at 25°, almost against the Lower Dunscombe limestone. The oval spot of the latter rock on the old map is somewhat out of place and shape, as its eastern half encroaches on ground which is occupied by Culm-measures. The shaly limestone fragments strewn over the field above the quarry are, in my opinion, derived from the outcropping top beds of the quarry, and are not higher beds.

My first introduction to the locality was by Mr. Lee, who, I believe, discovered it, and I observed to him that I thought most of the specimens belonged to the genus *Clymenia*, which opinion I formed from the elliptical figure,[1] and the absence of proof of dorsal siphuncle, at least among my specimens. Subsequently I showed some to Mr. Etheridge with the same query, to which he assented. I now think that in most cases the outline was due to pressure and distortion, which has much flattened the body-chambers.

I had the pleasure of accompanying Prof. Römer and Mr. Lee to Lower Dunscombe and the Culm-measures round Chudleigh, and was lucky enough to find two or three imperfect but wholly uncrushed specimens, which at once dispelled the notion of ellipticity. One especially, about the size of Prof. Römer's figure of *Goniatites intumescens* in "Lethæa Palæozoica," has the identical sutures of that form, but is round-backed instead of rather keeled; this, however, is probably dependent on sex. It is also obviously dorso-siphunculate. There is no body-chamber remaining, the air-chambers being filled with crystalline calcite, so that the shell when perfect was considerably larger. *Goniatites retrorsus* also occurs in these beds, but is rare.

Two or three specimens of *Cardiola retrostriata*, Keyserling, have come under my notice at the same spot. In the Oberscheld beds with *Gon. intumescens*, the little shell is as abundant as in the shales of Büdesheim, or the cleaved indurated marls of Saltern Cove. This

[1] As, for instance, in *Clymenia sub-nautilina*, Sandberger.

fact is known to me from having seen Mr. Lee's series lately brought from Oberscheld.

There is no doubt whatever that Prof. Römer[1] has identified a very interesting horizon in England, with one lithologically and palæontologically the same in Germany. Still, I should hesitate before accepting the foregone conclusion that there are no *Clymeniæ* present—especially not having seen Mr. Reid's specimens, *C. valida* and *C. striata*, as specifically determined by Mr. Etheridge,—for the following reasons, namely, the Labrador Bay pebbles out of Trias near Teignmouth contain undoubted *Clymeniæ* as well as *Goniatites*; one specimen cut quite true in the axial plane shows an uninterrupted ventral siphuncle to the innermost whorl. Another Labrador pebble contains two individuals of *Cardiola retrostriata*. The matrix of these is an indurated red calcareous clay, not differing materially from the Lower Dunscombe top beds.

Again, the Clymenien-Kalk of Silesia is, in colour and 'shelvy' fracture, identical both with the Oberscheld and Lower Dunscombe beds, and I would suggest that, unless some clear, continuous section is known which exhibits the Clymenia stage well above the *Gon. intumescens* stage, the distribution of these genera may be rather of a colonial nature, than of succession in time, *i.e.* stratigraphical. The thickness of the group may of course vary considerably in different areas.[2]

Having begun by criticizing Mr. Reid's palæontological remarks, I hasten to observe with what pleasure I have verified over the ground the fault which he described as throwing down the Culm-measures on the west of the Chudleigh limestone and subjacent slates.[3] The picturesque 'Chudleigh rock' is cut off at its S.W. end by a N.W. and S.E. fault, which steps Mr. Reid's fault forward in the same direction to a little beyond Lewell House, whence it (the strike fault) runs in a south-westerly direction under the 'Bovey Lake,' and reappears on the opposite side directly in line, as the well-known fault which throws the Culm-measures against the Bickington limestone and associated rocks (see Phillips, Pal. Foss., and Dr. Holl, Q.J.G.S. 1868). From Lemonford its course towards the granite at Skeriton has been described by Dr. Holl, as well as some of the transverse faults that shift it, and I believe it has a more important bearing upon the structure of S. Devon than has yet been recognized, The S.E. fault above mentioned runs to Oldchard Well, bringing the Culm-measures against the Ugbrook House limestone, the junction of the two series beyond the ponds being marked by a line of swamp.

It is necessary to stop here and not drift further from the original question, but we hope to resume on a future occasion, and discuss the *unfaulted* relations of the Culm-measures to the Devonian limestones on a wider basis, and to this vital question most of the above

[1] Geol. Mag. April, 1880.

[2] Since this has been in the printer's hands, I have seen a beautiful polished section of *Gon. multilobatus*, Sandb. (see Prof. Römer, *l.c.*), from Labrador Bay, in the collection of Mr. Vicary, F.G.S., of Exeter. Either there were two sources whence the pebbles with Cephalopoda were derived, or, as hinted in the text, the two faunas are less defined upon separate horizons than they have hitherto been supposed to be.

[3] Geol. Mag. Dec. II. Vol. IV. p. 454.

is but a little pioneering. We will only so far anticipate as to say that there is nothing whatever in the thin beds at Lower Dunscombe alone, to warrant the supposition that they constitute a passage from Devonian into Carboniferous.

VII.—A Contribution to the Study of the British Carboniferous Tubicolar Annelida.

By R. Etheridge, Jun., F.G.S., F.R.P.S.Edin.

(*Concluded from p.* 307.)

III.—Genus *Serpula*, Linnæus, 1758.

(*Systema Naturæ*, ed. 10, p. 786.)

Obs.—As distinguished from *Serpulites*, the term *Serpula* is here made to include those tubes which were attached, or in all probability attached by some portion of their surface to other objects, and in which there is an absence of the thickened margins, and the posterior bifurcating shelly tubes of the former. The name can only be used in an approximate sense, for it is quite within the bounds of possibility that any of the species here referred to *Serpula* may be shown to have other affinities. Already two out of the limited number of British Carboniferous species have been so indicated. The fine rigid siliceous rods formerly called *Serpula parallela*, M'Coy, are now known to be the anchoring fibres of a sponge allied to *Hyalonema*,[1] whilst it is more than probable that *Serpula hexicarinata*, M'Coy, is the corallum of a species of *Heterophyllia*.

13.—*Serpula indistincta*, Fleming. (Pl. VII. Figs. 30–32.)

Dentalium indistinctum, Fleming, Edinb. Phil. Journ. 1825, xii. p. 241, t. 12, f. 2.
Serpula compressa, J. de C. Sowerby, Min. Con. 1829, vi. p. 201, t. 598, f. 3 (non Eichwald).
„ „ M'Coy, Synop. Carb. Lime. Foss. Ireland, 1844, p. 168.
„ „ Bronn, Index Pal. Nomen. 1848, p. 1136.
„ „ Brown, Foss. Conch. 1849, p. 329, t. 98, f. 26.
Serpulites compressus, Morris, Cat. Brit. Foss. 1854, 2nd ed. p. 93.
„ „ Bigsby, Thes. Dev.-Carb. 1878, p. 243.
(Compare *Serpula subcincta*, Portlock, Geol. Rept. Londonderry, 1843, p. 362.)

Sp. char.—Tube thick, shelly, smooth, shining, slightly tortuous, or flexuous, somewhat compressed, tapering, not coiled upon itself, or in any way convoluted, or twisted. Section usually elliptical, at times approaching to the round. Surface smooth, or with indistinct annulations.

Obs.—In 1825, the Rev. Dr. Fleming described, under the name of *Dentalium indistinctum*, an elongated, tapering, and somewhat curved tube, which, from its want of symmetry, it would be difficult to regard as a *Dentalium*. Dr. Fleming described this fossil thus: "Shell about two and a half inches long, and nearly half an inch in diameter. The surface when entire is smooth, dull, and of a whitish colour. It consists of several layers, the surfaces of which have a shining mother-of-pearl aspect . . . . In the limestone of the Coal formation of West Lothian."

He adds, "Specimens of this *Dentalium* were sent to the late

[1] Prof. F. Roemer now places this in his genus *Acestra* (Lethæa Geog. 1880. 1 Th. 1st lief. p. 318).

Mr. Sowerby in 1814; but he delayed giving a figure in his "Mineral Conchology" in expectation of receiving more satisfactory examples."

There can be no doubt these remarks did not meet the eye of Mr. J. de Carle Sowerby, who continued the publication of the "Min. Con." after the death of his father, for in 1829 we find him publishing the same fossil under the name of *Serpula compressa*, the description and figure being those of the identical specimen forwarded by Dr. Fleming to the elder Mr. Sowerby. This specimen, preserved in the Geological Collection of the British Museum, even now retains the original label, bearing on it this note—"Mr. Jno. Fleming, Mar. 22, 1814," clearly proving it to be that spoken of by Dr. Fleming in his description before quoted.

I have examined the type specimens of *Serpula subcincta*, Portl., from the white Armagh limestone, and I believe it to be identical with the present species. In some specimens the tapering curved form of the tube of the former is quite similar to that of the latter, the only points of difference being that the section appears to be more circular, although one specimen before me is decidedly elliptical; and the surface is more strongly annulated, and has concentric thread-like striæ. It should, however, be stated that both in the type specimen of *S. compressa*, and in another example from Scotland now before me, so many of the shelly layers have peeled-off that it is not altogether easy to assert what were the surface characters. They may have been, therefore, quite similar to those of Portlock's species. I have refrained from placing the latter's name in the list of synonyms on this account, although, if not identical, I feel convinced their relation is a very close and intimate one.

By M'Coy this species, although placed in *Serpula* with doubt, appeared to him to be "more allied to *Serpulites* than to *Serpula*." Morris makes a direct reference to the former genus. The shelly and pearly nature of the tube would tend to bear out the views of these authors; but if, as M'Coy has stated, the forked, posterior termination of the tube is more a generic than a specific character in *Serpulites*, the species now under consideration must for the present remain in *Serpula*, because, so far as I know, this feature has not been observed in it.

To whichever genus *Serpula indistincta* may prove to belong, it can be distinguished from our two Carboniferous species of *Serpulites*, *S. carbonarius*, and *S. membranaceus*, by the section, which is elliptical, by the absence of the bounding raised borders of those species, and by the much thicker and more shelly nature of the tube; lastly it is of very rare occurrence.

According to Mr. Macleay,[1] *S. indistincta* approaches nearest to the Silurian species *Serpulites longissimus*, Murch.

Loc. and Horizon.—"Limestone of the Coal formation of West Lothian" (*Fleming and Sowerby*); from the appearance of the matrix I should suppose this to be one of the Bathgate limestones. A small specimen came under my notice a few years since from the

[1] Annals Nat. Hist. 1840, iv. p. 388.

strata at Gameshill Quarry, near Stewarton, connected with the lowest or Howrat Limestone (= the Main or Hurlet lime) of the Ayrshire Field (*Mr. A. Macconochie*). In the Museum of Practical Geology, there is a specimen labelled "Kilbride," probably meaning East Kilbride.

14.—*Serpula Torbanensis*, Etheridge, jun. (Pl. VII. Fig. 33.)

S. Torbanensis, Eth. jun., Mem. Geol. Survey, Scot. Expl. 31, 1879, p. 80.

Sp. char.—Tube elongate, either folded upon itself into a more or less oval loosely arranged coil, or many times convoluted and twisted in an irregular manner, but always with a tendency to assume the former condition; coils sometimes piling towards the centre; section probably circular, or the tubes may have been a little angular; surface longitudinally wrinkled; size of the coils from $1\frac{1}{2}$ to 3 lines in diameter.

Obs.—I cannot refer this form to any of the Carboniferous Annelids with which I am acquainted. Although exceedingly conspicuous, little can be said in the way of description from the coiled and sometimes contorted manner in which its remains are preserved and converted into carbonate of iron. This has to a certain extent altered the surface-markings of the tubes; but it has, on the other hand, rendered its presence in the black ironstone so very conspicuous, that it becomes necessary to, at least, designate the species by a name, more especially as, with the exception of a small Anthracoptraform shell, occasionally seen, the *Serpula* is the prevailing fossil in the ironstone. *S. Torbanensis* occurs in the latter in thousands, at times scattered generally through the matrix, but at others grouped into small clusters of an inch or two in extent. It recalls to us certain of those forms met with in younger rocks, rather than those we are accustomed to meet with in Carboniferous strata. Of the latter it approaches nearest to *Serpula* (*Spirorbis*) *helicteres*, Salter, but is quite distinct.

Loc. and Horizon.—Pits at Boghead, Barbuchlaw, and Coppers, near Bathgate, in Blackband ironstone above and below the Boghead parrot coal (Torbane-hill mineral). *Mr. J. Bennie.*

15.—*Serpula vermetiformis*, sp. nov. (Pl. VII. Fig. 34.)

Sp. char.—Tube vermetiform, or obtusely turriculated, the whorls coiled one above the other, but with the exception of the two last scarcely touching. Each whorl is cut across by a series of constrictions on the upper part, and placed at irregular distances from one another. Surface dark and shining, with slightly wavy, transverse, delicate, and almost smooth annulations.

Obs.—The tube of the specimen described is wound round a *Productus*, and there are traces of six whorls or turns of the tube, although it is probable from the appearance of the specimen that more existed.

The constrictions placed at irregular distances along the tube have much the appearance presented by any yielding substance when tied across by a string or other confining medium.

As I cannot refer this to any described species of Carboniferous worm-tube with which I am acquainted, I propose for it the trivial name of *vermetiforme*, in allusion to its general resemblance to some forms of *Vermetus*. *S. vermetiforme* approaches nearest to *S. Archimedis*, De Koninck, but having compared it with examples of this species in the National Collection, I can pronounce on their distinctness. It wants the strong transverse ridges and elongated drawn-out form of the latter.

I am indebted for the loan of the specimen to the Rev. G. Oldridge de la Hey, of Marple, Cheshire, who found the specimen, and forwarded it through Dr. H. Woodward.

Loc. & Horizon.—Castleton, Derbyshire, in Carboniferous Limestone.

16.—*Serpula?* (or *Serpulites?*) sp. ind.

Obs.—I gave a figure, published in a paper in a late number of the Proceedings of the Glasgow Nat. History Society,[1] of what appears to be a *Serpula* boring into a Crinoid stem. The tube in question is small, dark, and shining, with the peculiar bluish-bloom so often seen on the tubes of the Carboniferous *Serpulites*. Little more can be said about it, but we may hope for further specimens when the true character may be revealed.

Loc. & Horizon.—Woodend Quarry, near Fordel, Fife (*Mr. J. Bennie*).

IV.—Genus *Vermilia*, Lamarck, 1818.

(Hist. des Anim. sans Vertebres, v. p. 368.)

Obs.—The genus was proposed by Lamarck for tubes adhering by their whole length to submarine bodies, cylindrical in form, attenuated towards their posterior termination, more or less twisted, and with a round aperture frequently having from one to three projecting denticles.

Vermilia is met with to a certain extent in Secondary rocks, but increases in species in the Tertiary formation. So far as I am aware, only one Carboniferous species has been described, *V. minuta*, Brown, and another in the Permian of this country by Prof. King, *V. obscura*. It is, however, not improbable that *Serpula minuta* of Eichwald[2] may be referable to this genus, in which case the name will require alteration so as not to clash with *V. minuta*, Brown.

V. minuta as figured by Brown is a small, simple, curved, horn-shaped body, and appears to be rare. It is quite different to the more or less convoluted Carboniferous tube attached to Crinoid stems one is accustomed to meet with under this name in Collections, which much more closely resembles *V. obscura*, King, as very justly stated by Messrs. Armstrong and Young.[3]

I have never had the satisfaction to examine a specimen in anything like a good state of preservation, and will therefore not perpetuate the mistake, I have in common with others frequently before made, but will simply refer to this species as *Vermilia* (sp. ind.); indeed, I have not seen any clear proof that it is a *Vermilia* at all.

[1] Vol. iv. pt. i. t. i. f. 18 and 19.

[2] Bull. Soc. Nat. Moscou, 1856, No. 2, p. 407; Lethæa Rossica, 1860, i. p. 671, t. 34, f. 5

[3] Trans. Geol. Soc. Glasgow, iii. App. p. 23.

17.—*Vermilia?* sp. ind. (Pl. VII. Fig. 35.)

Sp. chars.—Tube tortuous, twisted, or curved, but never coiled upon itself in the form of a spiral; attached to the surface of submarine bodies, usually Crinoid stems and plates, by its whole length. Section subangular to round, but it is more usually seen in a compressed form; surface as a rule plain, or with indistinct transverse striations.

Obs.—As before observed, Brown's figure of *V. minuta* represents a small horn-like tube which cannot possibly include such a twisted or curved form as the present one, unless indeed the figure is wretchedly bad. The surmise of Messrs. Armstrong and Young is probably nearer the truth, that the Carboniferous form met with in Scotland is more allied to *V. obscura*, King, than to Brown's species.

Loc. and Horizon.—Skateraw Quarry, near Dunbar, in shale over the Skateraw Limestone; L. Carboniferous Limestone Group; and various other localities (*Mr. J. Bennie*).

V.—Genus *Ortonia*, Nicholson, 1872.

Ortonia, Nicholson, Geol. Mag. 1872, Vol. IX. p. 447.
,, ,, Brit. Assoc. Rept. for 1872 (pub. 1873), pt. 2, p. 119.
,, ,, Pal. Ontario, 1874, pt. 1, p. 122.
Conchicolites, Miller (pars), Cat. American Pal. Foss. 1877, p. 206.

Gen. char.—Animal solitary, inhabiting a calcareous tube, which is attached along the whole of one side to some foreign body. Tube slightly flexuous, conical, in section cylindrical, or somewhat flattened laterally, and subtriangular. Walls of the tube thick, and marked by annulations, which may, or may not extend completely round the tube (*Nicholson*).

Obs.—The genus *Ortonia* was proposed by Prof. H. A. Nicholson to include small Tubicolar Annelides of the Silurian rocks, which are solitary, and adherent to foreign bodies along the whole of one side of the tube. The genus *Conchicolites*, Nicholson, includes essentially social tubes which are only attached by their bases to foreign bodies, grow up vertically side by side, and are often closely united laterally to one another.

Ortonia is only accidentally social or aggregate, and is essentially a solitary form. *Cornulites*, on the other hand, includes tubes which are always free, at any rate when grown up. The original diagnosis of *Ortonia* described the genus as possessing a peculiar cellular zone down the unattached side of the tube; but as this is confined to the type species, *O. conica*, and as two other Silurian species have since been described, *O. minor* and *O. intermedia*, in which this zone is not met with, Prof. Nicholson now abandons this character as of generic importance. Judging from the structure of *O. intermedia*, the tube would appear to be made up of a succession of imbricating conical segments, the upper edges of which produce the encircling ridges or annulations.

Mr. A. S. Miller has, in his "American Palæozoic Fossils," placed *Ortonia* as a synonym for *Conchicolites*; but as Prof. Nicholson still maintains their generic distinction, I prefer following his opinion, especially as, so far as I know, no reasons have been assigned for the above union.

Through the researches of Mr. John Young, F.G.S., a form has been met with in the Carboniferous shales of Scotland possessing characters which appear sufficiently near to place them within generic affinity of *Ortonia*, Nich.

Both Pacht and Eichwald have described forms which appear to me to be inseparable from *Ortonia*. The *Serpula Devonica* of the former[1] is described as a small slightly bent tube, never becoming spiral, but tapering towards one extremity, and marked with indistinct growth-striæ. It occurs at Kon-Kolodes on the Don, associated with *Spirifer Anossoffi*. *Serpula striatula*, Eichwald,[2] is a conical, curved, and attenuated tube, flattened on the attached side, convex on the free, but with the cavity of the tube circular. The free surface bears unequal, close, transverse striæ, which are continued as lateral fringes on the object of attachment; it is of Devonian age, adhering to examples of *Favosites polymorpha* and *Cyathophyllum flexuosum*. We have in this latter species a point of much interest in the development of the growth-striæ into a lateral fringe on each side, impinging on the object to which the tube is attached, and in this respect resembling *Ortonia intermedia*, Nich.

18.—*Ortonia carbonaria*, Young. (Pl. VII. Figs. 37–40.)

O. carbonaria, Young, Geol. Mag. 1873, Vol. X. p. 112.
,, ,, ,, Proc. Nat. Hist. Soc. Glasgow, 1876, ii. pt. 2, p. 223.
,, ,, Bigsby, Thes. Dev.-Carb. 1878, p. 243.

Sp. char.—Tube small, conical, and straight, or slightly curved; attached wholly by one side, or only a portion of it. Section circular. Surface ornamented by sharp, continuous, annulations or rings separated by interspaces of variable breadth, but usually a little wider than the ridges themselves, and crossed longitudinally by innumerable fine microscopic striæ.

Obs.—This remarkable little organism is usually found loose with other minute fossils on washing the weathered shales from various localities, or is met with attached to the species of *Producti*, which appears to be its natural habitat. It possesses characters which render it of peculiar interest in connexion with the Silurian species described by Prof. Nicholson. In the first place, there is no cellular zone, as in the type species *O. conica*, thus showing a tendency towards *O. minor* and *O. intermedia*. Secondly, the annulations of the surface are crossed by very fine, in fact quite microscopic, longitudinal striæ, a character not found, to my knowledge, in any of the Silurian species; and lastly, I have in one or two specimens observed a tendency towards the imbricating nature of the segments described by Prof. Nicholson in *O. intermedia*.

The measurements of this very *Orthoceratite*-looking little tube, given by Mr. Young, are—length $\frac{1}{8}$ to $\frac{1}{4}$ inch; diameter of the tube at the larger end $\frac{1}{20}$ to $\frac{1}{30}$ of an inch; annulations, 35 in the space of $\frac{1}{4}$ of an inch.

Ortonia carbonaria differs from all the other species of the genus

[1] Beiträge zur Kenntniss d. Russ. Reiches, 1858, xxi. p. 107, t. 4, f. 5.
[2] Lethæa Rossica, i. p. 672; Atlas, f. 34, f. 4, *a.-c.*

at present known by being attached at times only by a part of its surface on one side of the tube, and in the presence of the longitudinal microscopic striæ. It agrees with *O. minor* and *O. intermedia* in the absence of the cellular zone described as existing in *O. conica*, whilst the absence of any lateral expansions at once separates it from *O. intermedia*, and *O. striatula*, Eichwald. On the whole, it probably is most nearly allied to *O. minor*, Nich., and *O. Devonica*, Pacht.

Loc. and Horizon.—Found at a large number of localities, amongst which may be mentioned—Galabraes Quarry, near Bathgate, in shale below the Bathgate Limestone; Roscobie Quarry, near Dunfermline, in shale above the Roscobie Limestone; Fullarton Quarry, near Edinburgh, in shale between the bands of the No. 2 Limestone; Fulwood Old Quarry, near Carluke, in shale above the main limestone, all horizons in the Lower Carboniferous Limestone Group (*Mr. J. Bennie*).

Shore, east of Ravenscraig Castle, Fife, in shale above the Gair Limestone; Westerhouse and Gair Quarries, in shale above the Gair Limestone, horizons in the Upper Limestone Group (*Mr. J. Bennie*). The typical locality given by Mr. Young is Brockley, near Lesmahagow.

VI.—Genus *Ditrupa*, Berkeley, 1835.

(Zool. Journ. v. p. 426.)

Gen. char.—"Shell free, tubular, open at both ends" (*Berkeley*).

Obs.—Certain fluted, or ridged tubes, found in the Carboniferous rocks of Vise and Tournay, have already been referred to Berkeley's genus *Ditrupa* by Baron de Ryckholdt, under the name of *D. Carbonifera*.[1] Judging from the figure this does not appear to partake of the characters usually met with in this genus in a sufficiently clear manner to render it absolutely certain that we are dealing with a species of it. The same author's *Ditrupa Devonica* appears to be a more satisfactory determination, even to the presence of the transverse wrinkles or undulations of the surface. If truly a *Ditrupa*, then the latter species is the oldest form on record, being found in Devonian rocks.

The following species, which I now describe under the name of *Ditrupa Ryckholdti*, comes much nearer in general characters to the recent species than does that of Baron de Ryckholdt, from Vise and Tournay.

19.—*Ditrupa Ryckholdti*, sp. nov. (Plate VII. Fig. 41.)

Sp. char.—Tube small, elongate, slightly curved, plain, smooth and hollow, tapering very gradually, with a few small constrictions towards the larger end, giving to the surface a broadly annulated appearance; ornament none.

Obs.—Side by side with the figure of this little fossil I have given one of a recent *Ditrupa*, from the coast of Madeira. This comparison will at once show the very close resemblance existing between the two. In Pl. VII. Fig. 42, the recent form, are seen numerous constrictions commencing at about the middle of the tube and continuing

[1] Mém. Cour. etc., l'Acad. R. de Belgique, 1852, xxiv. p. 125, t. 6, f. 25.

as far up as the contracted margin of the mouth. In another specimen of the recent species, there is an absence of constrictions, but a more lengthened and contracted mouth than in the former figure; whilst in a third example the constrictions are visible much lower down than in either of the other examples, and the mouth is comparatively little contracted.

Turning, now, to the minute fossils, which I believe to be referable to *Ditrupa*, we in the first place observe one, Pl. VII., in which the constrictions are very numerous and well-marked; another, in which they are continued regularly between the two apertures; and lastly, a third example, in which the constrictions are almost absent.

Dr. Bigsby [1] gives *Ditrupa Carbonifera*, De Ryckholdt, as occurring at Craigenglen in Stirlingshire, but I am not acquainted with the published reference to this.

Ditrupa Ryckholdti may be distinguished from both the species described by De Ryckholdt by its much smaller size, the regularity of its ornamentation, and the very slight curvature of the tube.

Loc. and Horizon.—Woodend Quarry, near Fordel, in shale above the No. 2 Limestone of the L. Carboniferous Limestone Series (*Mr. J. Bennie*).

VIII.—On the Association of Stibnite and Cinnabar in Mineral Deposits.

By J. G. H. Godfrey, F.G.S.

THE association of stibnite and cinnabar appears to have been first noticed at El Haminat,[2] in the province of Constantine Algiers, where, during the years 1850 to 1852, considerable quantities of both these minerals have been raised from veins traversing Cretaceous schists. Other localities in Algiers showing the same association are: Ghelma near Phillipsville, where cinnabar in crystalline crusts covers and penetrates antimony ochre derived from the decomposition of stibnite, the containing rock being a saccharoidal limestone; Debar, 19 kilometers to the N.W. of Ghelma, where stibnite is found covered with spots of cinnabar, the gangue being heavy spar; Traia, showing a similar occurrence to the preceding; Tasselemet, where radiating crystals of stibnite occur imbedded in earthy cinnabar.

In Mexico, at Hentzuco, cinnabar has been observed as a coating upon stibiconite, showing pseudomorphs after stibnite. Recently Dana [3] described a new mineral, Livingstonite, which had been discovered at the mine Ayoque de Huitzero, Mexico, in a matrix of carbonate and sulphate of lime, together with sulphur, cinnabar, stibnite, and valentinite. This mineral, of a hardness 2, spec. gr. 4·81, occurs in prisms and columnar groups like stibnite.

[1] Thes. Dev.-Carb. p. 243.

[2] Guide pratique de minéralogie appliqué, par A. F. Noguès, Paris, 54, rue des Saints frères, vol. ii. pp. 131. Notice sur les gîtes mineraux et les materiaux de construction de l'Algerie, par M. Ville, ingenieur en chef des Mines, Ann. des Mines, 6th série, tom. xvi. 1869, p. 161.

[3] Dana, System of Mineralogy, 5th edition, vol. ii. appendix, p. 35.

Its colour is bright lead-grey and its streak red, not black as with stibnite. According to an analysis by Barcena, its composition has been found nearly to correspond to the formula $4\,Sb\,S^2 + Hg\,S + Fe\,S^2$.

In Nevada and New Zealand, stibnite and cinnabar are said to be found associated with each other, but the author is not aware of any publications about this association.

A few years ago cinnabar in considerable quantity was discovered in the refuse heaps of the Meria antimony mines[1] situated in the commune of Ersa, Cape Corse, in the island of Corsica.[2] Lodes, containing the antimony chiefly as sulphide rarely as oxide, occur there in serpentine, talcose schists, or metamorphic limestone. They usually run from nearly N.W. to S.E., vary in width from a few inches to 11 ft., and are composed of stibnite (stibiconite), cinnabar in greatly varying quantities, iron pyrites and as gangue, fragments of the containing rock, clay resulting from the decomposition of the same, quartz, calcite and but rarely gypsum. Experience has shown that when calcite becomes predominant as gangue, no cinnabar is found associated with the stibnite. In the Castello lode stibnite in fine needles occurs dispersed throughout the calcite, which forms there the main constituent of the lode. The calcite, which retains its crystalline form, is more or less darkened according to the quantity of inclosed needles of stibnite. It frequently occurs, that in some large rhombohedral masses of calcite some of the corners are rendered dark by the presence of stibnite, whereas the remainder retains its original white colour.

Cinnabar, always in the amorphous state, occurs in these lodes; either filling up the interstices left between the crystals of stibnite (Seraggio lode), or intimately mixed with amorphous stibnite, and also in the shape of thin (up to half an inch thick) ribs inclosed in amorphous stibnite (Vallone and Fossato lodes).

The presence of intimately intermixed cinnabar in amorphous stibnite is always indicated by irridescence of the latter, and this property is made use of in separating ores containing cinnabar from those which are composed of amorphous stibnite only. The Vallone and Fossato lodes yield at present mixed antimony and cinnabar ores in considerable quantities.

The observed facts appear to prove that in these lodes the deposition of cinnabar has taken place subsequent to that of stibnite, and most likely also subsequent to that of calcite, which appears to form the chief mineral of the Castello lode.

In Tuscany, near Selvena, situated close to Santa Fiora, an association of stibnite and cinnabar has also been observed. Cinnabar occurs there, usually in small crystals, seldom in small lumps, in clay-seams interstratified with Nummulitic limestone. The layer of limestone at their junction has been found impregnated with fine

[1] First discovered at the Spellonche lode, where the ore picked from the refuse is said to have contained 28 per cent. of mercury.

[2] See also: Hollande, Géologie de la Corse, Ann. des Sciences géologiques, 1877, p. 105.

needles of stibnite, but no stibnite occurs with the cinnabar contained in the clay-seams. Close to Selvena exists a solfatara discharging carbonic acid and sulphuretted hydrogen in large quantities; and it appears highly probable, that this solfatara has played an important part in the formation of these deposits.[1]

REVIEWS.

I.—Early Man in Britain, and his Place in the Tertiary Period. By W. Boyd Dawkins, M.A., F.R.S., etc., etc. 8vo. pp. 537, 168 Woodcuts. (London: Macmillan & Co.)

THE literature of Man's antiquity grows apace. Lyell, Lubbock, Stevens, Evans, E. B. Tylor, James Geikie, and Prof. Dawkins himself have contributed volumes bearing more or less directly upon the subject. His ancient stone implements and weapons, his flint-chips, his megalithic monuments, have been described in detail. The evidence of his antiquity and early history both at home and abroad has been summed up; and his contemporaneity with large mammalia now extinct in this country has been admitted by all capable of forming an opinion upon the subject. His relation, however, to the "Great Ice Age," is still a matter undergoing investigation—it is a vexed question, and geologists will therefore turn to Prof. Dawkins's new work with eagerness to learn the opinion of one who has had such wide and varied experience of the subject. In his former work on "Cave-hunting" (published in 1874), the author dealt with a particular portion of the evidence; in the present work, though it naturally embodies the results of the former one, he treats generally of man's early occupation of Britain, as deciphered by the geologist, the archæologist, and the historian.

The author commences with a brief sketch of the history of life through past ages, and he observes that "The invasion of Europe by the placental mammals is the great event which is the natural starting-point for our inquiry into the ancient history of man, since the conditions by which he was surrounded, on his arrival in Europe, form part of a continuous sequence of changes, from that remote period down to the present day."

Existing orders and families of the placental mammalia are known to us for the first time in the Eocene period. The fauna and flora and geographical changes of the period are, however, described at more length than seems necessary (24 pages), with a full-page illustration of "Mid Eocene Forest of Bournemouth, overlooking Lagoon." Such matter would seem more appropriate to a manual of geology, especially as in a concluding paragraph headed "Man not here," Prof. Dawkins says, "It is obvious that man had no place in such an assemblage of animals as that described in this chapter. To seek for highly-specialized man in a fauna where no living genus of placental mammal was present would be an idle and hopeless

[1] See in connexion with this subject: A Contribution to the History of Mineral Veins by J. A. Phillips, F.G.S., Quart. Journ. Geol. Soc., vol. 35, p. 390.

quest." A view which is the natural result of belief in the theory of evolution.

In the Miocene[1] period living genera of Mammals begin to appear. And in the chapter devoted to this subject the author refers to the difficulty of distinguishing between Eocene and Miocene. "The only clue to their geological date (he says) is the stage of evolution presented by the mammalia, the more general having obviously preceded in point of time the more special forms"—a doctrine set forth at length in a paper he recently communicated to the Geological Society of London, on "The Classification of the Tertiary Period by means of the Mammalia." Although such a classification would be undoubtedly useful, we cannot help thinking it would be most inconvenient and undesirable to allow it to alter our present classification, which should be based on the evidence of physical conditions and changes, rather than on the occurrence of any particular fossil forms.

He regards the Hempstead Beds as Miocene, for they yield remains of a hog-like animal (*Hyopotamus bovinus*), found in Lower Miocene strata on the Continent. By most authorities they have been regarded as Eocene; but Professor Judd now places them as Oligocene. The physical changes of this period are dwelt upon, and the author introduces a section through Beinn More, the volcano of Mull, from a paper by Prof. Judd, which seems to us as out of place as the ideal picture from "Nature" by Mr. Starkie Gardner, before mentioned.

In the Miocene period we come upon the first supposed traces of Man—evidence resting on certain "splinters of flint" found in the Mid-Miocene strata at Thenay, and on a notched fragment of a rib of *Halitherium* from Pouancé, in France. These data appear to Prof. Dawkins insufficient to establish a Miocene man. If the flints were splintered artificially, he suggests that this was done by one of the higher apes then living in France rather than by man. He remarks that "The evolution of the animal kingdom, recorded in the rocks, had at this time advanced as far as, but no further than, the *Quadrumana*, and it seems to me not improbable that some of the extinct higher apes may have possessed qualities not now found in living members of their order." Indeed, Prof. Dawkins considers it highly improbable that man was then living in any part of the world, for "no living species of land mammal has been met with in the Meiocene fauna."

In the Pliocene strata at least one living species of mammal has been found, "therefore the improbability of man having lived in Europe at that time is proportionally lessened." In his chapter on this formation Professor Dawkins refers to the evidence of Ice-action in Pliocene times, to the Flora, and to the Mammalia in general; he discusses the development of antlers in deer, and

[1] Prof. Dawkins, following John Phillips, spells the words as Meiocene, Pleiocene; it seems to us better to follow Lyell (the originator of the terms), and use Miocene and Pliocene—a mode of spelling generally adopted. For the benefit of students uniformity is desirable.

points out the retreat of apes owing to the lowering of the climate. He regards the evidence of Pliocene man in France and Italy as unsatisfactory; and concludes that it is very improbable that he will ever be proved to have lived in this quarter of the world at that remote time, owing to the number of extinct species of mammals which characterize the Pliocene deposits. Further, he regards it as an open question whether man lived in early Pleistocene times, in which, however, he includes (very unfortunately, we think) the Forest Bed of Norfolk.

The Forest Bed is so intimately connected with the Crag of Norfolk, that if the former be placed as Pleistocene, so also must the latter. The observations of all who have made a careful study of the Pre-glacial beds on the Cromer coast testify to this, and it is only necessary to refer to the works of Lyell, of Mr. John Gunn, Prof. Prestwich, and Mr. Clement Reid in support of the statement. Indeed the Westleton Beds which Prof. Dawkins places in the Newer Pliocene (p. 72) are described by Prof. Prestwich as above the Forest Bed. This is only another instance of the futility of attempting classification on restricted palæontological evidence. Since the work was published three species of Carnivora new to the Forest Bed have been recorded.[1] It is quite true that there may be no hard line of demarcation between the Pliocene and Glacial deposits, but there is a considerable change of conditions between them, and it seems decidedly most convenient to regard the Pleistocene period as commencing in Glacial times.

Prof. Dawkins gives lists of Mammals showing those that survived from the Pliocene, and the living and extinct species of new comers. The lists of Mammals from the Pre-glacial Forest Bed of Norfolk being now in course of revision by Mr. E. T. Newton, we may pass over the subject, merely observing that *Trogontherium*, and *Arvicola amphibia,* noticed as "new comers," have been found in the Norwich Crag.

In what the author terms the "Middle Pleistocene" the arctic mammalia begin to appear—in this division he groups the beds at Ilford, Grays Thurrock, Erith, and Crayford. Referring to the discoveries of flint-flakes at the last-named locality, which he considers as the earliest evidence of man in this country, he observes that the strata "are very interesting from the possibility that they may belong to a time before the glacial climate had set in." And he mentions a superficial deposit at Ilford that "bears unmistakable signs of having been accumulated by the action of ice." This stratum, however (as he points out), was termed loess by Professor Prestwich, and "trail" by Mr. O. Fisher, and is a deposit very distinct from the Chalky Boulder-clay, which caps the heights on the north of the Thames Valley. The physical structure of the Thames Valley indicates that the deposits in it may be newer than the Chalky Boulder-clay; but there is no positive evidence.

The clearest cases of man's arrival before the close of the Glacial period are those brought forward by Mr. Skertchly; to these Prof.

[1] E. T. Newton, Geol. Mag. Dec. II. Vol. VII. p. 155.

Dawkins devotes but little space, observing in a foot-note, that "I feel inclined to accept the evidence brought before the British Association at Sheffield, in 1879, founded on the sections at High Lodge, Culford, Mildenhall, West Stow, and Broomhill, in favour of man having lived in East Anglia before the Upper Boulder-clay had ceased to be deposited." It is unfortunate that Mr. Skertchly has not yet published the detailed accounts of his discoveries, a fact which no doubt retards the acceptance of his views.

Prof. Dawkins is unable to accept the evidence for the existence of fossil man in interglacial beds in Switzerland.

We need not dwell upon the account of the abundant remains of Palæolithic man in what the author terms late Pleistocene times, in river-beds, and in caves. The social condition of the people and their domestic pursuits are the subject of comment, and he points out distinctions between the River-drift man and the Cave-man, the latter of whom he regards as represented by the Eskimos.

We have now reached the middle of the book, and here we leave what may strictly be called the Geological portion, and pass into the Archæological. We take leave of Palæolithic man, and are introduced to his Neolithic successor. The period we now enter upon is that called the Pre-historic, and which, succeeding the Pleistocene, carries us on to the Historic. To the general reader this will prove the most interesting portion of the subject. In the chapters devoted to it the physical condition of Britain and the manners and customs of its various inhabitants are described. Through the periods of polished stone, bronze, and iron—from the incoming of Iberian and of Celt to that of Anglo-Saxon, the author carries his readers, pointing out the domestic animals and the plants introduced, and dealing with many other topics, which finally lead us on to the time when History commences, and to the conclusion of his work. Thus, as will be seen, the work contains matter that will interest students in many branches of science; and the careful and cautious way in which the evidence of man's early occupation of Britain has been set forth, will command the respect of those who cannot understand the doctrine of his great age.

In summing up the evidence of Man's antiquity we find we have yet much to learn. No steps have been taken to indicate the time of his first appearance, nor has any progress been made in indicating the process of his creation. Prof. Dawkins remarks that the earliest inhabitant "comes before us, endowed with all human attributes, and without any signs of a closer alliance with the lower animals than is presented by the savages of to-day." H. B. W.

II.—Second Geological Survey of Pennsylvania.

1. Part I. The Northern Townships of Butler County. Part II. A Special Survey made in 1875, along the Beaver and Shenango Rivers. With four Maps and 154 Vertical Sections. By H. M. Chance.
2. The Geology of Lawrence County. A Report on the Correlation of the Coal-measures in Western Pennsylvania and Eastern

Ohio. By J. C. White. With Geological Map and 134 Vertical Sections.

3. Second Report of the Progress of the Laboratory at Harrisburg. By A. S. McCreath. (Harrisburg, 1879.)
4. Atlas to the Coal Flora of Pennsylvania and of the Carboniferous Formation throughout the United States. By Leo Lesquereux. Eighty-seven Plates with Explanations. (Harrisburg, 1879.)
5. The Permian or Upper Carboniferous Flora; or West Virginia and S.W. Pennsylvania. By W. M. Fontaine, M.A., and J. C. White, A.M. With thirty-eight Plates. (Harrisburg, 1880.)

THESE volumes form a continuation of a series of reports and papers (now about thirty in number) published by the Board of Commissioners of the Second Geological Survey of Pennsylvania, under the direction of J. P. Lesley (State Geologist) and an efficient staff of assistant geologists.

No. 1. This volume contains the results of certain special geological surveys made by Mr. Chance while acting as assistant to Mr. Carll, in the Baltic County Oil Region in 1876, and also of the more systematic survey of the fifteen northern townships which he afterwards made in 1878. The first six chapters are devoted to the general geology of the district, which chiefly consists of the Carboniferous Series, including the Lower Barren-measures, and the Lower Productive Coal-measures, and the Beaver River or Conglomerate Series; the surface features being modified by anticlinal and synclinal folds as well as by the effects of pre-glacial and glacial action. Chapters 6—10 give the detailed geology of the different townships, and of the Oil-fields of Butler County.

No. 2. In this report Prof. White describes the geology of Lawrence County, the rocks of which belong exclusively to the Coal-measure and sub-Carboniferous formations, of which detailed descriptions are given in chapters 2 and 3. The surface features have been moulded by glacial action, but unlike Butler County there is an absence of folds, for the forces which uplifted the strata to the south-east along the Alleghanies seem to have expended their activity before reaching Lawrence. Prof. White attributes the marked difference in the contour of the northern and southern halves of the county with the distribution of the drift. During the Glacial epoch the ice-sheet moved southwards, ploughing down all the northern part pretty much to the same level, forming wide level areas on the summits of the hills, while south of the glacial area no such planing down of the pre-glacial hills took place, and thus this part of the county is much more broken and rugged than the Northern.

Appended is a special report on the correlation of the Coal-measures of Western Pennsylvania and Eastern Ohio. This and the preceding report are illustrated with geological maps and numerous vertical sections, and are supplemented with a series of indexes giving an exhaustive summary of the contents of the reports.

No. 3. The Laboratory report, by Mr. A. S. McCreath, contains a series of analyses classified to some extent both geologically as well as geographically, of coal, coke, iron ores, firebricks, and clays, and miscellaneous minerals, which must form a very useful addition in connexion with the industrial resources of the county.

No. 4. This volume consists of eighty-seven neatly executed plates illustrative of the Coal Flora of Pennsylvania, by Prof. Leo Lesquereux; it is simply an atlas with explanations of the figures on the plates and some references to previous works, but without any detailed descriptions of the species or of their localities.

No. 5. This is a report on the Permian or Upper Carboniferous flora of West Virginia and South-western Pennsylvania, by Profs. Fontaine and White, which, besides a detailed description of the species illustrated by thirty-eight plates, contains a sketch of the geology of the Carboniferous formation of Western Virginia, describing, in ascending order, the lithological and other characters of the sub-divisions of the Carboniferous rocks, the Vespertine, Umbral shale and Conglomerate groups, the Lower Productive Coal-measures, Lower Barren-measures, Upper Productive Coal-measures (containing two of the most extensive and persistent Coal-beds of the Appalachian Coal-field), and Upper Barren-measures, with notices of their respective floras.

The authors consider, that while the lower six groups belong to the Carboniferous, the Upper Barren-measures should be referred to the Permian age, from the study of the plants and the evidence derived from other sources.

The flora shows a marked decadence of characteristic Carboniferous forms. Of the 107 species found in the Upper Barrens of West Virginia, twenty-two occur in the Coal-measures proper, while twenty-eight are found also in the Permian of Europe. Some appear to be exclusively or at least characteristic forms, as *Callipteris conferta*, *Alethopteris gigas*, and *Odontopteris obtusiloba*. Many of the Pecopterids and Neuropterids exhibit Permian features, and the Sphenopterids differ much from the Carboniferous, and show affinities with Mesozoic forms. There is no Lepidodendron, and only one or two species of Sigillaria and Calamites. The evidence of important physical change at the beginning of the series, their lithological character, the disappearance of coal, and the diminution of the animal and plant life, further substantiate the Permian age of the beds.

Should this conclusion be correct, it will have, the authors say, "an important bearing on the history of the changes which have affected the physical geography of our portion of the North American continent. Our great Appalachian Revolution would have occurred at the close of the Permian period, and instead of standing almost alone, would be in harmony with those mighty changes which elsewhere operated at the close of the Permian to extinguish the forms of Palæozoic life." J. M.

III.—The Geological Record.

In the early part of the present year we received the fourth volume of the Geological Record, being an account of the works on Geology, Mineralogy, and Palæontology, published during the year

1877, with supplements for 1874—76. The volume maintains the high character of those preceding it for fullness, accuracy and method, and it is not too much to say that geologists owe a large debt of gratitude to its painstaking editor Mr. Whitaker, and to its several sub-editors and contributors. Such recognition, moreover, is especially due when we remember that the work, which must in its preparation often prove irksome and uninteresting, is undertaken by busy men who devote to it their leisure hours and private time without any remuneration whatever. There is no need to testify to the value of the work. Whoever attempts to keep up with the progress of the science, cannot do so by any individual effort, while to the specialist the labour that the Geological Record ought to save must be very great. We say *ought to save*, because, owing to the increasing delay in the publication of the work, we question whether it can fulfil many of the requirements of those actually engaged in particular researches. This delay must greatly interfere with its present value. It is true that as a work of reference each volume will from year to year become more valuable, but those who subscribe are apt to look upon it in a personally utilitarian point of view. Great difficulty arises, as we are told by the editor, from the impossibility of noting many publications until long after they have appeared, and this remark no doubt refers especially to the foreign publications. Such difficulties and delays require that the plan of the Geological Record should be in some way altered to allow of a more speedy issue of the annual volume than has at present been found practicable. The volume for 1879 ought now to be in the hands of subscribers.

It has been suggested that as soon as sufficient material has been accumulated, a volume might be published, irrespective of the date of publication of the works. This plan, however, would not only entail more labour on the editor and subscribers, but be productive of some confusion. The simplest plan, it seems to us, would be to print merely the titles of foreign papers. Then probably it would not be difficult to largely increase the number of contributors, who had only to send in a list of titles from time to time. Short abstracts of all works published in Britain might still appear. By some such alteration in plan, it is to be hoped that the Geological Record may be enabled to continue, and to increase the sphere of usefulness that it has so well commenced, and by which it has so much assisted in the advancement of Science.

REPORTS AND PROCEEDINGS.

Geological Society of London.

June 23, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Skull of an *Ichthyosaurus* from the Lias of Whitby, apparently indicating a new species (*I. Zetlandicus*, Seeley), preserved in the Woodwardian Museum of the University of Cambridge." By Prof. H. G. Seeley, F.R.S., F.G.S.

In this paper a very fine skull of *Ichthyosaurus* was described in detail. From the broad triangular form of the skull and the great distance between the orbits, the author is led to regard it as belonging to a species distinct from any that have hitherto been described. As it was presented to the Woodwardian Museum by the Earl of Zetland, he proposed to name it *Ichthyosaurus Zetlandicus*.

2. "Note on the Cranial Characters of a large Teleosaur from the Whitby Lias, preserved in the Woodwardian Museum of the University of Cambridge." By Prof. H. G. Seeley, F.R.S., F.G.S.

The author described a somewhat fragmentary cranium from the Whitby Lias, which has been sawn through along the median line so as to expose the brain-cavity. From the characters thus revealed he is led to infer that the resemblance of the Teleosaurs to the existing Crocodilia has been somewhat too strongly insisted upon. From the peculiarities of the prootic bone, of the tympanic region, and the general shape of the brain-case, the author is led to regard the fragment as indicating a new species, for which he proposes the name of *Teleosaurus eucephalus*.

3. "On the Discovery of the Place where Palæolithic Implements were made at Crayford." By F. C. J. Spurrell, Esq., F.G.S.

The Brickearths of Crayford lie in a channel excavated from the Thanet Sand and subjacent Chalk. The flakes here described were found below the level of the top of the Chalk, on a sort of slope of sand. They form a layer, about 10 feet from N. to S., and 15 feet (perhaps more) from E. to W., which is at one end 36 feet, at another about 42 feet, below the present surface. The flakes lay touching each other, the larger sometimes being several inches thick; they are new and clean, though sometimes studded with calcareous concretions. Some were broken across, evidently before being covered. The author had been enabled to piece many together, and show that the manufacture of haches was the purpose for which they were fractured. Also he had found two pieces of a hache. Fragments of bone were found associated with the flints; among them was part of the lower jaw of *Rhinoceros tichorhinus*. The author regards these Brickearths as slightly newer than the Dartford gravel, which here caps the Thanet Sand, and in which flint implements have also been found.

4. "The Geology of Central Wales." By Walter Keeping, Esq., M.A., F.G.S. With an Appendix by C. Lapworth, Esq., F.G.S., on a new species of *Cladophora*.

The district described by the author is much contorted and disturbed, and offers great difficulties. The following classification of its deposits is proposed in descending order:—(3) The Plynlimmon Grits; (2) The Metalliferous Slates; (1) The Aberystwith Grits. (1) consists of dark grey grits and imperfectly cleaved slates; they are not very fossiliferous, Graptolites being most abundant. (2) A more argillaceous series of pale blue and grey colour, much folded. This series, near the Devil's Bridge, appears of extraordinary thickness; but the author believes that this is due to a great inversion or, rather, to a series of inversion-folds. Above this is (3) the Plynlimmon group. The area occupied by, and general characteristics of these groups were described in detail. Fossil evidence enables the author to correlate beds and constitute an order of succession in a considerable number of the sections. All three divisions, however, may be regarded as composing one great group, forming a great primary synclinal, with subordinate anticlinal folds along N. and S. lines. The relation of these beds to the Denbighshire Grits and Tarannon Shales has been investigated in neighbouring districts. The author regards the Plynlimmon Grits as representing a special gritty development in the Tarannon Shales, and so above the Llandovery Grits. The Metalliferous Slates and the Aberystwith Grits, an arenaceous development of their lower parts, represent the Llandovery group of the Survey, probably the Upper and a part of the Lower Llandovery. There does not appear to be any evidence of a break in this district between the Upper and Lower Silurian. This is confirmed by palæontological evidence, and in the study of the Graptolites the author has been assisted by Mr. Lapworth. These show that the Mid-Wales beds are on the horizon of the Upper Birkhill group of Scotland, and of the Coniston Mud-stones of the Lake-district. A table of fossils was appended to the paper, with a description of some new forms. The Appendix, by C. Lapworth, Esq., described a new species of *Cladophora*.

5. "On new Erian (Devonian) Plants." By J. W. Dawson, LL.D., F.R.S., F.G.S.

The paper first referred to recent publications bearing on the Erian (Devonian) flora of N.E. America, and then proceeded to describe new species from New York and New Brunswick, and to notice others from Queensland, Australia, and Scotland.

The first and most interesting is a small Tree-fern, *Asteropteris noveboracensis*, characterized by an axial cylinder composed of radiating vertical plates of scalariform tissue, imbedded in parenchyma, and surrounded by an outer cylinder penetrated with leaf-bundles with dumbbell-shaped vascular centres. The specimen was collected by Mr. B. Wright, in the Upper Devonian of New York.

Another new fern from New York is a species of *Equisetites* (*E. Wrightianum*), showing a hairy or bristly surface, and sheaths of about twelve, short, acuminate leaves.

A new and peculiar form of wood, obtained by Prof. Clarke, of Amherst College, Massachusetts, from the Devonian of New York, was described under the name *Celluloxylon primævum*. It presents some analogies with *Prototaxites* and with *Aphyllum paradoxum* of Unger.

Several new ferns were described from the well-known Middle Devonian plant-beds of St. John's, New Brunswick; and new facts were mentioned as confirmatory of the age assigned to these beds, as showing the harmony of their flora with that of the Erian of New York, and as illustrating the fact that the flora of the Middle and Upper Devonian was eminently distinguished by the number and variety of its species of ferns, both herbaceous and arborescent. It will probably be found eventually that in ferns, equisetaceous plants, and conifers, the Devonian was relatively richer than the Carboniferous.

Reference was also made to a seed of the genus *Ætheotesta* of Charles Brongniart, found by the Rev. T. Broun in the Old Red

Sandstone of Perthshire, Scotland, and to a species of the genus *Dicranophyllum* of Grand'-Eury, discovered by Mr. J. L. Jack, F.G.S., in the Devonian of Queensland.

In all, this paper added six or seven new types to the flora of the Erian period. Several of them belong to generic forms not previously traced further back than the Carboniferous.

The author uses the term "Erian" for that great system of formations intervening in America between the Upper Silurian and the Lower Carboniferous, and which, in the present uncertainty as to formations of this age in Great Britain, should be regarded as the type of the formations of the period. It is the "Erie Division" of the original Survey of New York, and is spread around the shores of Lake Erie, and to a great distance to the southward.

6. "On the Terminations of some Ammonites from the Inferior Oolite of Dorset and Somerset." By James Buckman, Esq., F.G.S., F.L.S.

The author referred to the figures given by D'Orbigny of Jurassic Ammonites having the mouth-termination perfect, and proceeded to describe the characters presented by complete specimens obtained by him from the Inferior Oolite of Dorsetshire and Somersetshire. He enumerated 14 species, which he classified as follows, in accordance with the nature of the terminations:—1. Termination lanceolate, *i.e.* with a lance-shaped process on each side of the mouth (*A. concavus, subradiatus, Eduardianus*); 2. Ovato-lanceolate or spathulate, *i.e.* with a spathulate process on each side of the mouth (*A. Braikenridgii, linguiferus, Sauzii, Martinsii, subcostatus*); 3 Delphinulate "side view like that of the classic dolphin" (*A. Gervillii*); 4. Semicircular (*A. Brongniarti, Manselii, Humphresianus*); 5. Waved (*A. Moorei, boscensis*).

7. "Faröe Islands. Notes upon the Coal found at Suderöe." By Arthur A. Stokes, Esq., F.G.S.

The coal in this district is associated with shales, and these are interbedded with sheets of basalt and dolerite. It is worked after a primitive fashion by the natives. Some of the seams are more than half a yard thick. There are two varieties of the coal or, rather, lignite, containing respectively 51·7 and 68·2 per cent. of carbon. The author gave details of sections and other matters connected with the coal-bearing area, and various notes upon the geology of the district.

8. "On some new Cretaceous *Comatulæ*." By P. Herbert Carpenter, Esq., M.A. Communicated by Prof. P. Martin Duncan, M.B., F.R.S., F.G.S.

In this paper the author described five new species of *Antedon* from British Cretaceous deposits, two of them in the possession of the Rev. P. Brodie, the rest in the collection of the British Museum. The species are: *Antedon perforata* and *A. Lundgreni*, from the Upper Chalk, Margate; *A. striata*, from the Upper Chalk, Dover; *A. laticirra*, from the Chalk of Wylye, Wiltshire; and *A. incurva*, from the Upper Greensand, Blackdown. The author further gave a tabular key to the known English Cretaceous species of *Antedon*, and in conclusion referred to certain peculiarities in the structure of these fossils, apparently subservient to the circulation of water in their interior.

9. "On the Old Red Sandstone of the North of Ireland." By F. Nolan, Esq., M.R.I.A. Communicated by Prof. Hull, LL.D., F.R.S., F.G.S.

The rock classed on maps of the north of Ireland as Old Red Sandstone is of two kinds, the lower and larger portion chiefly conglomerate of felstone, schist, grit, passing into sandstones, cut off by a fault on N. and N.W. from metamorphic rocks, and resting near Pomeroy, in the N.E., on fossiliferous Lower-Silurian. Associated with these are sheets of lava, probably submarine, from which the above felstone-pebbles have been derived; these are porphyrite. Near Recarson, also, are vesicular melaphyres, whether contemporaneous or intrusive is doubtful. There is also an intrusive granite, which alters the sandstones into quartzites, and is prior to the upper series now generally held to be basement conglomerate of the Carboniferous. This, formerly coloured as Old Red Sandstone, is unconformable with the other, which it much resembles. The lower conglomerates have been considered Lower Old Red Sandstone; the author showed that these bear great resemblance to parts of the Dingle series of the South of Ireland. In the North of Ireland the upper conglomerates are succeeded by sandstones, and these by Carboniferous Limestone. The author regards the upper conglomerates as representing the Upper Old Red Sandstone of Waterford (the Kiltorcan beds of the south not being identifiable in the north); and the overlying sandstones as the equivalents of the Carboniferous shale and Coomhola grit, and, in Scotland, of the Calciferous Sandstone.

10. "A Review of the Family Vincularidæ, Recent and Fossil, for the Purpose of Classification." By G. R. Vine, Esq. Communicated by Prof. P. M. Duncan, M.B., F.R.S., F.G.S.

The author examined in detail the insufficient description of the genus *Vincularia* by its founder Defrance, and the manner in which it has been employed by subsequent authors. He concluded that the different forms, ranging from the Carboniferous to the present day, which have been included in the genus, present no such features in common as would justify the retention of the generic or family name.

11. "On the Zones of Marine Fossils in the Calciferous Sandstone Series of Fife." By James W. Kirkby, Esq. Communicated by Prof. T. Rupert Jones, F.R.S., F.G.S.

In this paper the author described the marine beds that he has met with in the Calciferous Sandstones of the east of Fife, and traced the sequence of over 4000 feet of beds, probably all belonging to the "Cement-stone group." In the section from the west of Pittenween to Anstruther he recognized eighteen zones, which he characterized by their contained fossils; in the section at Randerstone he distinguished eleven limestone beds; and he compared and, as far as possible, correlated the two series of deposits. Full lists of fossils were given, and the author further specially discussed the characters and distribution of the more important species.

12. "The Glaciation of the Orkney Islands." By B. N. Peach, Esq., F.G.S., and John Horne, Esq., F.G.S.

In this paper, which forms a sequel to their description of the Glaciation of the Shetland Isles, the authors, after sketching the geological structure of Orkney, proceeded to discuss the glacial phenomena. From an examination of the various striated surfaces, they inferred that the ice which glaciated Orkney must have crossed the islands in a north-westerly direction, from the North Sea to the Atlantic. They showed that the dispersal of the stones in the Boulder-clay completely substantiates this conclusion; for in Westray this deposit contains blocks of red sandstone derived from the island of Eda, while in Shapincha blocks of slaggy diabase, occurring *in situ* on the south-east shore, are found in the Boulder-clay of the north-west of the island. Again, on the mainland, blocks of the coarse siliceous sandstones which cross the island from Inganess to Orplin are met with in the Boulder-clay between Honton Head and the Loch of Slennis.

Moreover, they discovered in the Boulder-clay the following rocks, which are foreign to the island:—chalk, chalk-flints, oolitic limestone, oolitic breccia, dark limestone of Calciferous-sandstone age, quartzites, gneiss, etc., some of which closely resemble the representatives of these formations on the east of Scotland, and have doubtless been derived from thence. From this they infer that, while Shetland was glaciated by the Scandinavian *mer de glace*, Orkney was glaciated by the Scotch ice-sheet, the respective ice-sheets having coalesced on the floor of the North Sea and moved in a north-westerly direction towards the Atlantic.

They also found abundant fragments of marine shells in most of the Boulder-clay sections, which are smoothed and striated precisely like the stones in that deposit. They conclude that these organisms lived in the North Sea prior to the great extension of the ice, and that their remains were commingled with the *moraine profonde* as the ice-sheet crept over the ocean-bed. From the marked absence of shell-fragments in the Shetland Boulder-clay, they are inclined to believe that much of the present sea-floor round that group of islands formed dry land during the climax of glacial cold.

CORRESPONDENCE.

DR. CROLL'S ECCENTRICITY THEORY.

Sir,—My letter in your March Number has not elicited any explanation from Dr. Croll, but has one from Mr. Wallace; in reply to whom I would observe that Mr. Croll not only admits that the eccentricity would be inoperative on climate but for its causing a diversion of the ocean currents, but he endeavours in great detail to show that the most important of all these currents, and the one on which the difference between the climates of Western Europe and Eastern North America depends, the Gulf Stream, was totally diverted and turned southwards along the coast of South America so as not to enter the North Atlantic at all.

The modification of Mr. Croll's theory which Mr. Wallace now offers we shall be better able to understand when his book appears; but to speak of the influence of the Polar extension of North

America on its climate is only to express in another form the influence produced by the currents, for it is simply because of this extension that the Gulf Stream does not reach the eastern shore of that part of America to which the comparison with Europe applies until it has passed through the refrigerator of the Polar Basin, and issued therefrom as the Polar, or Labrador current. Land not lofty, such as is most of that which forms the Polar extension of North America, has of itself no more refrigerating effect than sea which ameliorates climate only when warmed by equatorial currents, as the condition of the great Antarctic expanse of ocean sufficiently proves. I venture indeed to think that it has less so. Before Mr. Wallace can appeal to any ameliorating influence exerted on the climate of Europe by the Mediterranean (an influence to which the isothermals lend no countenance) as contrasted with America, he should show that the valley of the Mississippi was not submerged during the Glacial period. Some American geologists, as *e.g.* Dr. Newberry, insist that it was; and if so, not only would those conditions, on the absence of which Mr. Wallace relies, be present, but their influence be more considerable than any produced by the Mediterranean, because the water of the Gulf of Mexico, of which such submergence would form an extension, is hotter than that of the Mediterranean.

In testing Mr. Croll's theory, however, we may confine ourselves to North America alone. Owing to the Gulf Stream leaving the eastern shore where these differences begin, and to the Labrador current hugging it down to that point, while the western shore is throughout washed by the warm water of the Pacific, the climate north of the 40th parallel presents on the eastern and western coasts contrasts similar to, though not quite so great as those which obtain between the West of Europe and East of America. Now the glaciation on the eastern and western sides of America follows these existing differences of mean temperature just as it does in the case of Western Europe and Eastern America. Turn where we will, both in the northern and southern hemispheres, the climate of the Glacial period appears to have been an uniform diminution of mean temperatures as they now exist by virtue of geographical conditions and ocean currents; and it is this which in my mind points so strongly to that period having resulted from a cosmical cause wholly unconnected with these conditions, that is to say, to a diminution in the heat-emitting power of the sun. SEARLES V. WOOD, Jun.

July 9th, 1880.

P.S.—In my first letter I should have instead of "winter cold," said *mean temperature*, as it is this which regulates glaciation.

GLACIAL AND POST-GLACIAL.

SIR,—In answer to the geological questions set by my friend Mr. Dalton in the July Number of this MAGAZINE, I would remark that I know nothing in the brief notice of his "Geology of Colchester" that can be gainsaid. The statement that the *Bison*, *Elephas antiquus*, *E. primigenius*, etc., are forms "so distinct from those which are known to have inhabited this country in Post-Glacial times," requires no modification: it is a fact. Nevertheless as my remarks were made in the hope of eliciting some discussion. I will, with your consent, try to pass Mr. Dalton's examination. Thus the remarks on the term "Post-Glacial" were intended as a protest against the use, *without explanation,* of such a definite classification to beds whose age has been a matter of controversy; and when (as regards the district described) precision is not possible in the present state of the evidence. I use the terms Glacial and Post-Glacial in the same sense as the term Carboniferous is used, to mark periods of time, no matter what deposits took place, or what fluctuations of climate occurred. I hold that the Glacial period in Britain may very conveniently be regarded as synonymous with the Pleistocene and Palæolithic age; deposits with Palæolithic implements (Brandon Beds) having been discovered to be of strictly Glacial age, and such implements (where found in mammaliferous deposits) having as associates the group of animals in question. The passing away of the Glacial conditions in Britain allowed of the incoming of the present fauna. It might, of course, be said that as land-ice is now met with in the polar regions, we are still living in the Glacial period; with equal propriety might it be said that we are still living in the Pliocene or in the Cretaceous period, but there would be no limit to such diversions. We can no more expect to correlate our local divisions with those in other parts of the world, than we can make the reigns of our sovereigns correspond with those of rulers in other countries. The following classification seems best to meet the requirements of the case, the Pliocene beds being inserted in order to show their relations:—

Recent.	Historic	
	Neolithic and Prehistoric.	
Pleistocene.	Palæolithic and Glacial.	
Pliocene.	Upper Crag.	Forest Bed Series and Bure Valley Beds.
		Norwich and Red Crags.
	Lower Crag.	Coralline Crag.

Heath Villa, Fakenham,
July 3rd, 1880.

Horace B. Woodward.

British Museum (Natural History).—It will interest the scientific public to learn that the removal of the Natural History portion of the British Museum Collections to the new building prepared for their reception (on the site of the old 1862 Exhibition), in Cromwell Road, has actually commenced. The whole of the Mineralogical, and a portion of the Geological Galleries are closed to the public, and the collections are being steadily transferred. Mr. Lazarus Fletcher, M.A., F.G.S., has been appointed Keeper of Mineralogy, *vice* Professor N. S. Maskelyne, F.R.S., M.P., resigned. Dr. Henry Woodward, F.R.S., has been appointed Keeper of Geology, *vice* G. R. Waterhouse, Esq., resigned.

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By ROBERT NEEDHAM CUST,

Late Member of her Majesty's Indian Civil Service; Hon. Secretary to the Royal Asiatic Society; and Author of "The Modern Languages of the East Indies."

"*To me they represent thirty-five years of inquiry, reflection, and speculation. Many pages recall scenes in India, and friends, Natives and English, loved and valued, whom I shall see no more. The first Essay was written when I was acting as private secretary to Sir Henry Lawrence in the camp of Lords Hardinge and Gough, at the gates of Lahore, the capture of which is an old story now. The 'Indian District during a Rebellion' was written in the camp of Lord Canning, at Allahabád, while Sir Colin Campbell was still beleaguering Lakhnau. The Civil Judge decided his cases in one part of North India; the Collector got in his Land Revenue in another, at a distance of many hundred leagues from each other; but for any success in either vocation I was indebted to the rare good fortune of having sat at the feet of Lord Lawrence, and learnt my lesson from the greatest of administrators. Some were written in the tent under the shade of the mango-grove, or in the solitary staging-bungalow. Notes for others were jotted down on a log in a native village, or in a boat floating down one of the five rivers on the track of Alexander the Great, or in an excursion in the mountains of the Himálaya. The materials for others were collected in Palestine, Italy, France, Germany, and Russia, and pillaged from men and books in many languages, European and Asiatic. Such as they are, they reflect the turn of thought, the employment, the studies, and, no doubt, the weaknesses of the writer, viz., an ardent love for the people of India, a fearless spirit of inquiry into the history of the past, and a tendency to cast off all conventional shackles in the search for truth, and to look upon men of all ages and countries as stamped in the same mould, deformed by the same weaknesses, and elevated by the same innate nobility.*

"*Some of the last words of my master, Lord Lawrence, in India were, 'Be kind to the natives.' I would go even further, and say, 'Take an interest in and try to love them.' They are the heirs (perhaps the spendthrift heirs) of an ancient, but still surviving civilisation. And how far superior are they to the modern Egyptian, or dweller of Mesopotamia, the bankrupt heirs of a still more ancient but exhausted civilisation! How superior are they to the Equatorial and Tropical African, who never had any civilisation at all! It seems a special privilege to have lived a quarter of a century amidst such a people as the inhabitants of Northern India, who are bone of our Arian bone, if not flesh of our Occidental culture: a people with History, Arts, Sciences, Literature, and Religion not to be surpassed, if equalled, by the Chinese and Japanese, who, like the Indians, for so many centuries sat apart from, and uninfluenced by, the long splendour of the Greek and Roman civilisation, which had overshadowed the rest of the world.*"—EXTRACT FROM PREFACE.

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ORIGINAL ARTICLES.

I.—Oceans and Continents.

By T. Mellard Reade, C.E., F.G.S., etc.

IN opposition to the views enunciated by Lyell and the older geologists, and until now generally accepted by those who have made physical geology a study, an opinion is gaining ground that "generally speaking the great continents and great ocean basins have occupied their present positions through all geological time;" that they are, though subject to oscillations of level, permanent depressions and elevations produced by the gradual diminution of the earth's diameter through loss of heat and consequent sinking in of the rigid crust.

So far as I can learn, Dana appears to have originated the idea that the continents have been built up around portions of the crust of the earth that have first hardened—a sort of process of evolution; but whether he accepts the rigid position that the sites of the great continents and oceans are, within certain limits, unalterable, is not so clear. Mr. A. R. Wallace is the great champion of this latter idea, though his explanation of the mutations of the position of land and sea, as explained in his "Geographical Distribution of Animals," and incidentally in "Australasia," and other writings, seems to overstep the bounds of his theory. Mr. Murray, of the *Challenger*, seems also during his voyage to have been deeply impressed with the permanence of the abyssal depressions of the oceans, and I believe holds the opinion that the continents have occupied their present positions through all geological time, excepting as having developed in size, somewhat in the manner suggested by Dana and Le Conte.[1] In a late number of "Nature," without committing himself to any of the views just enumerated, Mr. Moseley, F.R.S., says that there were no signs of submerged continents discovered by the soundings and dredgings of the *Challenger*. Dr. W. B. Carpenter, in the "Nineteenth Century," has also written in favour of these new views of the general permanence of the present main features of the continents and oceans. Professor Alex. Agassiz, in "Nature," called attention lately to the fact that his distinguished father was one of the first to propound the view that the ocean basins are of great antiquity.

[1] For some of Mr. Murray's views on the subject see a paper by him "On the Structure and Origin of Coral Reefs and Islands," *Proc. Roy. Soc. of Edin.* April, 1880, published in abstract since the above was penned.

My first difficulty in regard to accepting these views arises from the "general" or undefined nature of the statements, which are put forward in a very crude form. The arguments relied on in favour of the fixity of continents and oceans are far from convincing, as I know of none, either general or particular, that cannot to my mind be as satisfactorily answered on the older hypothesis, that the land and water have in the world's history interchanged places so that at one time or another every part of the ocean-bottom may have been land.

Still further, in attempting to follow out the sequence of events by which oscillations of land and sea in a *limited* area could account for all those enormous and successive stratified marine deposits almost everywhere to be found on every continent, nay even on islands such as New Zealand, the mind actually fails to grasp what could have been the formative process.

All are agreed that subaerial waste of land is the main source of the detritus of which the rocks, of what on upheaval become other lands, are built.

It follows that where the marine deposits were going on, equivalent land must have existed elsewhere. Now the more we *limit* the area of oscillation of land and sea, the more difficult the explanation of the phenomena of geology becomes. Professor Archibald Geikie, F.R.S.,[1] states, in "Geographical Evolution":—"When the curtain of darkness begins to rise from our primeval Europe, it reveals to us a scene marvellously unlike the existing continent. The land then lay chiefly to the north and north-west, probably extending as far as the edge of the great submarine plateau by which the European ridge is prolonged under the Atlantic for 230 miles to the west of Ireland," and he goes on to calculate that the Silurian system in Great Britain "alone contains (or did contain?) 180,000 cubic miles of detritus derived from this land. Also that then the shallow sea which spread from the Atlantic southward and eastward over most of Europe was tenanted by an abundant and characteristic series of invertebrate animals" (Trilobites, etc.).

"But at the close of the Silurian period a vast series of disturbances took place, as the consequence of which we find the first rough outlines of the European continent were blocked out." "Then comes the period of the Old Red Sandstone, with its vast lakes abounding in bone-covered fishes, etc." "By the time of the Coal periods the aspect of the European area had still further changed." "It then consisted of a series of low ridges or islands in the midst of a shallow sea, or of wide saltwater lagoons." "All this time the chief area of high ground in Europe appears still to have lain to the north and north-west."

The next scene "brings before us a series of salt lakes covering the centre of the continent from the north of Ireland to the west of Poland."

"These salt lakes of the Triassic period seem everywhere to have been quickly effaced by a widespread depression, which allowed

[1] Geographical Evolution—Proc. Royal Geographical Society, 1879, pp. 422-43.

the main ocean once more to overspread the greater part of Europe." To this period, termed the Jurassic, "we can trace back the origin of a large part of the rock now forming the surface of the continent." The next long era was the Cretaceous. "During that time the Atlantic sent its waters across the whole of Europe and into Asia." When we turn to the succeeding geological period, that of the Eocene, the proofs of widespread submergence are still more striking. A large part of the Old World seems to have sunk down; for we find that one wide stretch of sea extended across the whole of Central Europe and Asia. After this, "the subterranean movements began to which the present configuration of Europe is mainly due." I give these copious extracts, because it is the first attempt I have met with to draw a definite picture of the process by which a continent has been built up, on the assumption that the great oceans and great continents as they exist now are, so to speak, permanent features of the earth. But does this description bear out such a theory? We have the Silurian, Carboniferous, Jurassic, Cretaceous and Eocene seas covering the greater part of what is now the continent of Europe, and the latter the greater part of Asia as well. Where at this time was the land? In the "north-west;" but that is a very general description of its whereabouts! We have Silurian strata stretching from New York to the Arctic regions, and Cretaceous and Tertiary strata in Greenland and Spitzbergen. The more we try to follow this complicated geological geography, the more it eludes our grasp. We cannot but admit to ourselves that the materials for anything like accurate pictures of the outlines of the geography of the so-called "periods" do not exist, and though it may be a useful exercise of the imagination to try and draw them, few deductions of any permanent value can in this way be made, much less can the foundations of a theory of the earth be laid.

Again, it is said that all the rocks we know of are shallow-water deposits, and have been laid down either as littoral deposits, or in shallow seas on the margins of land.

With seas in the various periods covering the principal portion of Europe and Asia, does not that fact, if admitted, constitute a greater difficulty in accepting Mr. Geikie's explanation than it does in the older idea of the general interchange of land and sea?

But I for one am not prepared to admit that the rocks of the earth are all of littoral or shallow-water formation. Professor Alex. Agassiz describes dredging up from over 1000 fathoms, 15 miles from land, in the Gulf of Mexico,[1] masses of leaves, pieces of bamboo, of sugar cane, dead land shells and other land debris, which he says would, if found fossil in rocks, be taken by geologists to indicate a shallow estuary surrounded by forests.

In my estimation these geologic pictures give no more correct a view of the *modus operandi* of the evolution of the geological features of the earth than does the strange view Dr. Carpenter credits some geologists with, that a sort of "See-Saw" has been

[1] Dredging Operations of U. S. Coast Survey, Steamer "Blake," 1879, Letter No. 3, pp. 294-5.

going on between the great oceans and great continents, by which first one is up, and the other down. Any one who holds such views must be strangely ignorant of physical geology.

The flatness of the ocean-floor is another argument urged against its ever having been land. I think, however, that those who use it would hardly realize what Europe or any other continent would look like if its configuration were traced only by soundings taken in, say, 3000 fathoms of water! Very probably the same argument would be used to prove that *it* had never been a continent.

In the mid-Atlantic, in what is called the Challenger Ridge, and its extensions, there are certain volcanic peaks, such as the Azores, St. Paul's Rocks, Ascension, Tristan da Cunha, etc. I ask, if these peaks had 1000 fathoms of water over them, should we know of their existence? Their position as they are now seen above the surface could only be ascertained and recorded by good navigators. What then would happen were they out of the range of vision with a deep ocean rolling over them? In all probability on the same ridge there exist submerged peaks of which we know nothing.[1] The great depths of the ocean are also urged as an argument against it ever having been the site of land; and when it is shown that the highest mountains measure vertically the greatest depths of the seas, it is, *per contra*, pointed out that these are only isolated peaks, while the ocean depths extend over thousands of square miles. But it has been shown by Professor Judd, F.R.S.,[2] that the strata of the Alps measure fully five miles in vertical thickness, and that the sea-floor must have subsided to that extent at least to allow of their deposition. Dana had previously shown this to be true of the Appalachians, and I have no doubt most high mountain ranges will tell a somewhat similar story. The Gulf of Mexico is over 2000 fathoms in its deepest part, yet there is just reason to suppose that it once formed part of the continent of South America.[3] In a paper "On the Caribbean Sea," *Nature*, July 15, 1880, p. 242, further soundings of the steamer "Blake" are described; one of the features discovered being "an extraordinary submarine valley," "in length 700 statute miles, from between Jamaica and Cuba, nearly to the head of the Bay of Honduras, with an average breadth of 80 miles."

Professor Geikie, in the paper quoted, also points out that Britain must have subsided at least three miles during the Silurian period, though he assumes deposition to have kept pace with subsidence, as indeed does Prof. Judd in the case of the Alps. To come to more recent times, in the Glacial period Great Britain subsided to the

[1] Mr. Murray says, in the paper before alluded to, on Coral Reefs, etc. (p. 507):—"The soundings of the "Tuscorora" and "Challenger" have made known numerous submarine elevations; mountains rising from the general level of the ocean's bed, at a depth of 2500 or 3000 fathoms, up to within a few hundred fathoms of the surface."

[2] Contributions to the Study of Volcanos, Geol. Mag. Dec. II. Vol. III. 1876.

[3] Dredging of the U. S. Steamer "Blake," 1879, Letter No. 3, pp. 299-301. Alex. Agassiz speculates on the former connexion of the West India Islands with the continent of South America.

extent of from 1400 to 2000 feet.[1] There is therefore no improbability in the sea-floor being raised to the extent even of five miles.

To say that no continent averages more than, say, 1200 feet above the sea-level, is no answer to this, as no doubt there must exist some general balance of stability of deformation in the globe. The reason the surface of the land ranges so little above the level of the sea points to the likelihood of any greater height being "unstable"; that the foundations of the earth would not bear any greater irregularity in the distribution of weight.[2] It must be kept constantly in mind also, that if the crust of the earth is mobile, the elevation of a mass of land of large superficial extension through water would require between $\frac{1}{3}$ and $\frac{1}{2}$ less effort than through air, therefore the "stress" on the foundations would be to that extent (the weight of the water) less.

If the continents are the portions of the earth that have first hardened, it is strange that it is just these hardened bosses that have to be most unstable, according to the further requirements of the theory, and the most subject to volcanic action. Nor is it probable that so large an area as the Pacific could have existed since the beginning of geological history with volcanos in its midst, without the growth of something more than the groups of small coral islands that now exist there.

According to the theory, also held by those in favour of the fixity of continents and oceans, that volcanic energy is dying out, in former times these Pacific volcanos must have been more active and numerous, and surely some land would have been built up from the bottom had other conditions been stable. But it may be alleged, and I believe is, that this has always been a subsiding area; that, in fact, independently of minor oscillations, all the deep seas are areas of subsidence, and all continents areas of upheaval, and have been since the beginning of time. This notion shows a strange ignorance of solid geometry or "fluid" geometry if so be it! for if the sea-floor of the Pacific, covering an area of the earth's surface nearly equal to that of all the land, has constantly subsided, where did the waters of the ocean, the bulk of which can hardly have increased, put themselves before the subsidence of the sea-bottom was complete or nearly complete? The answer is obvious—they

[1] Mr. Gwyn Jeffreys, F.R.S., in a paper recently read before the Geological Society, seems also to have been impressed with the evidences of recent subsidence and elevation as an argument in favour of the older views as to continents and oceans.

[2] Professor Judd writes me: "Why the mountain masses of the globe rise so little above the surface of the ocean I take to be due to the great rapidity of subaerial denudation in the higher regions of the atmosphere. The moon, which is a much smaller globe than ours, has much more prominent features. If the rate of waste gradually increases as we rise higher in the atmosphere (owing to inequality of temperature and condensation of moisture, etc.), then the tendency will be to keep down all great inequalities. All our mountains, therefore, are comparatively small, and all the highest are of recent formation geologically speaking."

This reasoning I thoroughly agree with as regards mountain masses, but the small average elevation of whole continents above the sea-level I think points to the possible instability of other conditions, mechanically speaking, and to the probable mobility of the crust of the earth as regards large areas.

must have occupied the place of what is now land, and we are thus reduced to the absurd conclusion that the continents which we are trying to account for could not exist until the subsidence had reached nearly its present limits, while the requirements of the theory demand the continuance of the subsidence to the present time. On the hypothesis of the interchangeability of land and sea, all this is readily explained. A movement of subsidence in the Pacific would be balanced by the upheaval of land elsewhere, so that the cubic capacity of the ocean-basins and cubic capacity of the land would remain nearly intact. The idea that the land has been upheaved by a continuous sinking of the ocean-basins (due to the shrinking of the earth or any other cause) can only be characterized as a geometrical impossibility.

There is still one aspect I must deal with, as it is a modified form of the same idea, which is rather prevalent. It is this, that the deeper parts of the ocean may always have been ocean. This statement possesses the misfortune to be, like most others on the subject, so intangible as to be difficult to deal with. What area does it take in? Were we to reduce it to dimensions, I think these "deeper portions," to make a joke, would no more "hold water" than the "continuously subsiding" great oceans. At all events it is a great pity we cannot examine by a boring these "cesspits of the ages," for should the idea prove true, the rejoicing geologist would find the records of marine life in unbroken sequence from the Laurentian to the present time. To conclude, there is still another general argument of great force against this notion of modified fixity of land and sea. It has already been pointed out by me in a paper on "Limestone as an Index of Geological Time."[1] The 'Porcupine,' 'Challenger,' 'Blake,' and other dredgings have shown that an enormous area of the sea-bed is covered with a calcareous ooze. It is well known that the materials of sedimentary rocks have been used up again and again, and their breaking up is usually preceded by a removal of cementing calcareous matter in solution—limestone being removed nearly wholly in a state of solution in water as carbonate or sulphate of lime. It is also well known and insisted upon by those who hold the views I am now combating, that the mechanical matter is deposited near to land—not in the deep oceans. It therefore follows as a corollary, that if the oceans have been fixtures, the carbonate and sulphate of lime has been continuously abstracted from the rocks and deposited in greater or less proportion in the ocean through incalculable ages, where it must remain to this day. It also would follow as a further consequence that the newer rocks would be less calcareous than the older ones.

The reverse of this is the case, as any one studying the valuable series of analyses made by Dr. Frankland, of water flowing from various formations in Great Britain, and published by the Rivers Pollution Commission in their sixth report, may find out for himself as regards England and Wales. The "Gnarled gneiss" of Norway, the old rocks of the Peninsular area of India, and the primary

[1] "Chemical Denudation in Relation to Geological Time," pp. 49–50.

formations of most countries, are distinguished by the comparative absence of calcareous matter; while on the other hand great rivers like the Parana flowing from newer formations, such as the Andes, show by their hardness the presence of calcareous matter in the rocks they flow from. And further, if there never existed any great continent on the site of the Pacific, a still further removal of lime, in addition to that in organic ooze, has been continuously going on from the beginning of time in the form of coral growth.

The subject is of such far-reaching importance, that I have put these few arguments together to enable those who differ from me to have the opportunity of refuting them.

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

Part III.

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

(PLATES XIII. & XIV.)

Genus Pseudomelania, Pictet et Campiche, 1861–64, Paléont. Suisse, 2me partie, Terr. Crét. de St. Croix, p. 266. (*Chemnitzia*, D'Orbigny, and *Phasianella*, D'Orbigny.)

It is not proposed to discuss the merits of the generic name applied to a group of Univalves so characteristic of and so abundant in the Jurassic rocks. *Melania*, *Eulima*, and *Chemnitzia* have each of them served in turn, and in adopting *Chemnitzia* after D'Orbigny, the late Dr. S. P. Woodward observed[2] that the "*Melaniæ*" of the Secondary rocks are *provisionally* referred to this genus. Pictet and Campiche include the *Chemnitziæ* and *Phasianellæ* of the Oolites in one genus *Pseudomelania*, thus preserving to a certain extent the old generic appellation.

Since it is almost impossible to regard the so-called "*Phasianellæ*" of the Oolites as in any sense belonging to the Turbinidæ, I have, with one exception, adopted Pictet and Campiche's generic name for the several species hitherto referred to *Phasianella*, whilst retaining the provisional name *Chemnitzia* for the rest, so as to produce the least possible amount of change in our lists.

In the Corallian rocks of Yorkshire one well-known species of *Chemnitzia* is extremely common, whilst there are three other very distinct species, of which at present only one, or at most two, specimens have as yet been found in this district. These species, with one exception, have been identified elsewhere.

7.—Chemnitzia Heddingtonensis, Sowerby, 1813. Plate XIII. Figs. 1*a*, *b*, *c*, *d*.

Melania Heddingtonensis, Sowerby, 1813, Min. Conch., tab. 39, fig. 2.

Bibliography, etc.—The type specimen is from the Coral Rag of Heddington. Sowerby gives a very characteristic figure of the shell in a reversed position. The peculiar bevelling of the upper part of the whorl is better shown than in D'Orbigny's figures (Ter. Jur., pl. 244), but the latter show the character of the aperture. A figure is

[1] Continued from the July Number, p. 298. [2] Manual of Mollusca, p. 126.

also given by De Loriol and Pellat (Jurassique Supr. du Boulonnais, pl. viii. fig. 4) of a shell from the Séquanien of Houllefort, which the authors refer to this species. If correctly drawn, it represents a specimen which has suffered somewhat from wear. On the whole, Sowerby's original figure is better for the purposes of specific identification, than any other known to me. Deslongchamps quotes this highly characteristic Corallian species from the Inferior Oolite of Normandy, but it is more than probable that D'Orbigny was right in rejecting this identification.

Description.—Fig. 1*a*. Specimen from the base of the Coralline Oolite at Pickering (my Collection).

Length (restored)	120 millimètres.
Width	30 ,,
Length of body-whorl to entire shell	34 : 100.
Spiral angle	21°.

Shell elongated, conical, subturrited anteriorly, not umbilicated. The spire increases under a regular angle of 21°. About 10 mm. of the apex is wanting. The upper whorls are smooth and almost flat, though sharply separated by the sutures. As the shell increases, a varix in the upper third of the whorl becomes more and more pronounced with each turn of the spire, and this is succeeded by a slight hollowing out of the middle of the whorl. Thus a most unmistakable character is imparted to the entire shell, as each of the lower whorls is angular above, depressed in the centre, and convex in the lower half. In this specimen the body-whorl is but slightly tumid. The lines of growth are unusually well preserved, the original shell substance being replaced by a brown-coloured spar, and it is even possible in places to discern a very minute punctate ornament arranged transversely (as shown in Fig. 1*c*).

Very large individuals of this species are found in the Malton Oolite, often beautifully preserved in white spar, but rarely with ornaments so sharp as in the specimen figured.

Fig. 1*b*.—Specimen from the Coralline Oolite of Ness (my Collection). Front view of a fragment with the shell in a very different state of preservation to the preceding, but showing the aperture favourably.

Length (restored)	117 millimètres.
Width	33 ,,
Length of body-whorl to entire shell	34 : 100.
Spiral angle	22°.

Outer lip slightly compressed (the edge is a little ragged); anterior margin of aperture very oval; posterior extremity pointed; inner lip of moderate thickness and encroaching but little on the columellar area.

Fig. 1*c*.—Specimen from the Coralline Oolite of Malton; and *Fig.* 1*d*.—Specimen from the Coralline Oolite of Ampleforth Beacon (my Collection).

These are representatives of *Chem. Heddingtonensis* in its earlier stages, when the whorls are perfectly flat. It will be seen that the larger specimen is just beginning to develope the varix, and has the punctate ornament unusually well preserved.

Relations and *Distribution.*—A form so prodigiously numerous as this cannot fail to have several relations. D'Orbigny has justly pointed out that, in the Inferior Oolite, *Melania coarctata*, Desl., has a strong resemblance, though with recognizable differences. As we ascend in the geological scale, *Chem. vittata*, Phil. (G. Y. pl. vii. fig. 15), from the Cornbrash of Yorkshire is so near a relative that it requires some discrimination to make out the differences. We are indebted to Dr. Lycett (Suppl. to Great Oolite Mollusca, p. 14, Plate xxxi. fig. 10) for a good figure and description of the Cornbrash species. The body-whorl, instead of being rounded off at the base, as in *Chem. Heddingtonensis*, presents a double varix, whilst the other whorls also are rather more angular, and the sutures more deeply impressed. In both species, however, the early whorls are flat, and there exists a similar arrangement of encircling granulated lines, so that the absorption of the lower varix, and the modification of some minor points, would suffice to convert *Chem. vittata*, Phil., into *Chem. Heddingtonensis*, Sow. Indeed it is by no means rare to find specimens in the Coralline Oolite of Malton where a lower varix is discernible. Who shall say that, during the long interval between the Yorkshire Cornbrash and the Yorkshire Corallian, these alterations were not gradually and naturally effected in portions of the Jurassic series, of which in Yorkshire at least we have now no traces?

The variations in the Corallian species itself are very considerable. D'Orbigny extends the limits of the spiral angle alone from 19°—33°; and certainly the specimens now figured are all about the lowest of these limits, though there are specimens from the Coralline Oolite of Malton and from the Coral Rag of Langton Wold with a wider base. On the other hand, the specimen, Fig. 1*c*, might almost come under the denomination of *Chem. Clio*, O'Orb., though I prefer to class it with the commoner form. Yet it is a matter of no small surprise that, amongst the enormous multitudes of *Chemnitzia*, so very few can be referred to any other of the many species described by D'Orbigny from the Oxfordian and Corallian of France. In North Germany likewise there seems to be an equal poverty of species, since Brauns[1] gives no more than three. Of these *Chem. abbreviata*, Rœm., though found in the shell-bed at the top of the Lower Calcareous Grit near Cumnor, has not yet been discovered in Yorkshire.

As regards distribution in Yorkshire, *Chem. Heddingtonensis*, so characteristic of our Coralline Oolite, is first known to me in the great shell-bed at the top of the Lower Limestones, towards the middle of the Tabular range, and thence upwards throughout the Coralline Oolite generally, but never in the main mass of the Lower Limestones nor in the Passage-beds connecting them with the Lower Calcareous Grit. Thus with us it is absent throughout the zone of *A. perarmatus*, or at least so rare as not to have attracted notice. Brauns,[2] however, quotes *Ch. Heddingtonensis* from the Heersumer Schichten of North Germany, as well as from the Coralline Oolite of that country, whilst D'Orbigny speaks of it as common throughout

[1] Obere Jura, p. 241.
[2] *op. cit.* p. 177.

the Oxfordian stage, but does not quote it as a Corallian form. As far as I can make out, without having actually visited the districts, the chief home of the species throughout the North-East of France is to be sought in those highly fossiliferous beds which go by the general name of "Oolithe ferrugineuse," and which, according to Buvignier, separate the "Argiles d'Oxford" from the "Coral Rag." Specimens sent to me by Dr. Barrois from about this horizon in the Ardennes are on the whole wider than the common Yorkshire form, and the base of the whorl in some of the specimens is less rounded off.[1] The evidence seems to point to the fact that *Ch. Heddingtonensis* flourished earlier in the Franco-German areas than in Yorkshire. The species is pretty plentiful in the Coral Rag of Oxfordshire, but is so rare in the shell-bed at the top of the Lower Calcareous Grit (zone of *A. perarmatus*) at Cumnor, which is full of other univalves, that I have never succeeded in finding it. A narrow form which may be referred to this species occurs in the Osmington Oolite at Weymouth, and more typical specimens in the *Trigonia*-beds. The highest position in which the shell has been found is the Upper Calcareous Grit of Silpho near Hackness.

8.—Chemnitzia Pollux, D'Orbigny, 1849. Plate XIII. Fig. 2.

Chemnitzia Pollux, D'Orbigny, 1849, Prod. de Paléont. Strat. vol. ii. p. 2.
Id. 1850, Terr. Jurass. vol. ii. p. 62; pl. 247, fig. 1.

Bibliography, etc.—The history of this species is a short one, as it seems to have been noted by few authors, unless it is concealed under some synonym which I have not yet been able to detect.

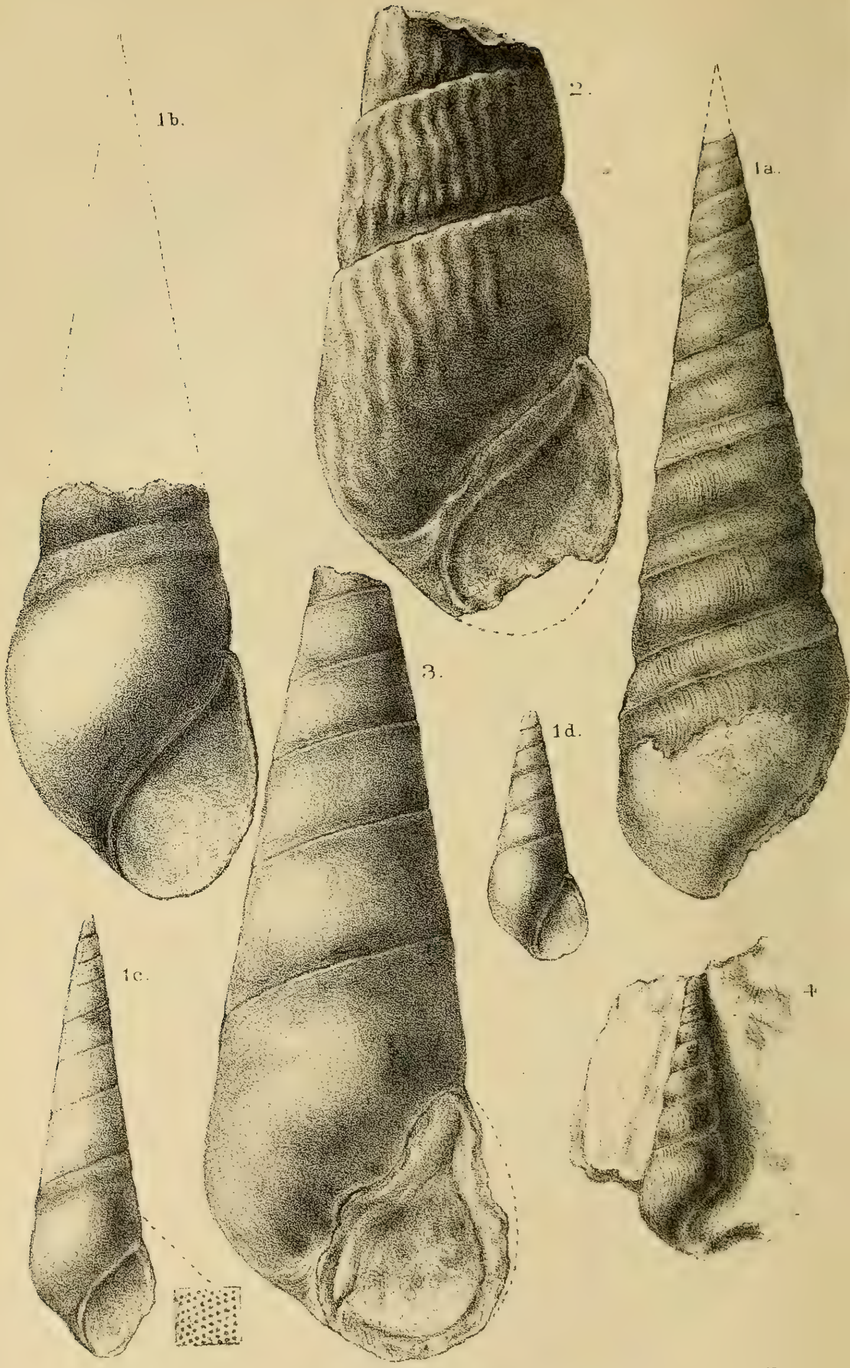
Description.—Specimen from the Coral Rag of Langton Wold (my Collection).

Length (restored)	123 millimètres.
Width	37 ,,
Length of body-whorl to entire shell	38 : 100.
Spiral angle	25°.

The following is D'Orbigny's description of the species: "Shell elongated, conical; spire formed of a regular angle composed of whorls almost flat, only marked by a very slight relief of the lower portion almost inappreciable; feebly developed lines of growth may also be noted. Aperture oval, rounded in front, pointed behind, and furnished on the columellar region and especially below with very marked thickenings."

This description fits the specimen under consideration remarkably well. The shell is a most complete cone, without any approach to a turrited shape, and the sutures are extremely shallow. It might

[1] This collection, stratigraphically arranged by Dr. Barrois, is one of great interest and value. The general fauna of the beds in question seems to be on a level with the whole of our Yorkshire Coralline Oolite and Passage-beds, including part of the Lower Calcareous Grit, though the actual association of fossils is not exactly the same. The prevailing ammonites are *A. cordatus* and *A. vertebralis* in several phases. The representative of the group *Perisphinctes* is principally the small form so common in the Lower Calcareous Grit of Cayton Bay, and *A. perarmatus* is very scarce.



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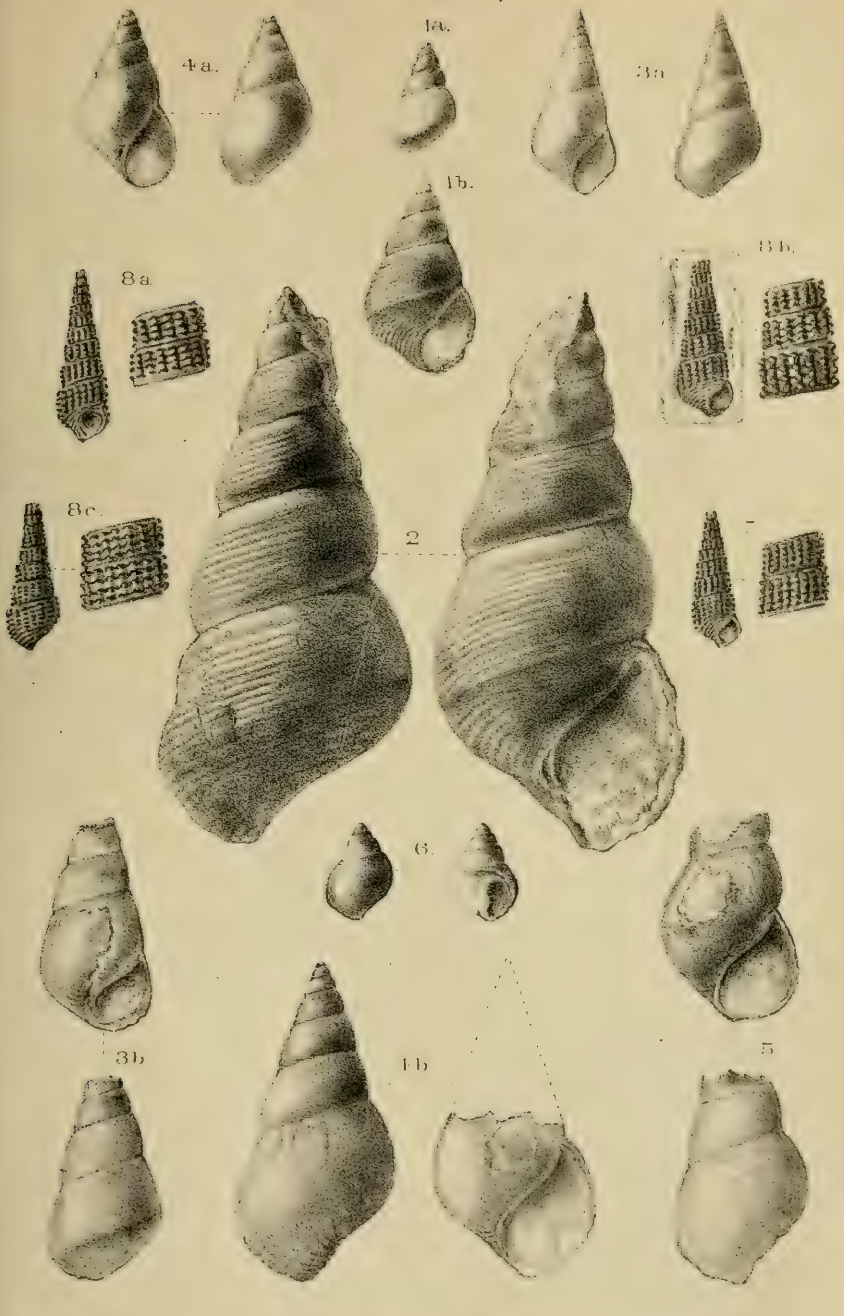
Mintern Bros. imp

Corallian Gasteropoda; Yorkshire.



A. S. Foord del. et lith.

Mintern Bros imp.

Corallian Gasteropoda; Yorkshire

perhaps be thought that rolling or abrasion has had something to do with the latter feature, and this may be so to a certain extent. Nevertheless the aperture is unusually well preserved, which shows that the specimen has not been subjected to very hard usage. The heaviness of the columellar lip, and the anterior rounding off, in such marked contrast to the oval outline of the anterior extremity of *Chem. Heddingtonensis* (see Fig. 1*b*), are very striking points. The shell substance also is immensely thick.

Relations and Distribution.—The affinities of this shell with anything hitherto found in Yorkshire are by no means obvious. The excessive flatness of the whorl separates it both from the *Heddingtonensis* group and from the *athleta* group. Whether it is to be regarded as an aberrant form, or is entitled to the indefinite rank of a species, I can hardly undertake to say at present. Yet the presence of such a shell, and the fact that it tallies so fairly with specimens found by D'Orbigny in the Corallian of Sainpuis (Yonne), and by Cotteau at Chatel-Censoir, is certainly worthy of being recorded. At the same time, when a "species" has been noted at very few localities, its qualifications are liable to suspicion, and one cannot help wondering where may be its head-quarters, since nothing of the kind has been noted in the Corallian of the South of England.

The specimen figured was found in the same quarry as *Ch. Langtonensis*, along with several rare and curious fossils. This serves still further to illustrate the remarkable character of the Coral Rag in the eastern portion of the Howardian Hills, and should stimulate collectors carefully to watch the quarries of that region.

9. — Chemnitzia Langtonensis, Blake and Hudleston, 1877. Plate XIII. Fig. 3.

Chem. Langtonensis, Bl. and H., 1877, Q.J.G.S., vol. xxxiii. p. 393, pl. xiii. fig. 3.

Specimen from the Coral Rag of Langton Wold (my Collection).

Bibliography and Description.—The following extract from the paper above quoted tells us all that is known of this peculiar shell:—

"Although this is an incomplete and unique specimen, its ornaments are so distinct that it can be confounded with no other *Chemnitzia*. It also possesses a remarkable callosity on the inner lip, which ought perhaps to separate it from this genus.

"Spiral angle 19°, angle of suture 130°. Total length $5\frac{1}{2}$ inches (estimated); last whorl 2 inches long, double the next whorl; whorls only moderately convex, least so in the upper part; suture not deep, but rather abrupt; ornaments irregular, undulating risings parallel to the length of the shell, numerous and close together."

One or two imperfect specimens which may belong to this species have turned up since the above was written, but nothing throwing any additional light on the case. Since the early whorls are unknown, they may be without any other ornament than what is due to lines of growth; and thus the immature shell may be represented by such a form as that shown in Pl. XIII. Fig. 4.

10.—Chemnitzia, cf. corallina, D'Orbigny, 1850. Plate XIII. Fig. 4.

Chemnitzia corallina, D'Orbigny, 1850, Terr. Jurass. vol. ii. p. 69, pl. 250, fig. 1, 2.

Bibliography, etc.—The specimen under consideration represents a group of *Chemnitzia* where the whorl is tumid in the early stages. The spiral and sutural angles are such that it might possibly be the immature form of *Ch. Langtonensis*, but this is merely a conjecture.

Description.—Specimen from the Coral Rag of the Malton district —most probably from Langton Wold (Leckenby Collection).

Length (approximate)	38 millimètres.
Width	11 ,,
Length of body-whorl to entire shell	38 : 100.
Spiral angle	20°.

Shell elongated, conical. The whorls increase under a regular angle of about 20°, and are convex, smooth, and devoid of ornament beyond the lines of growth, which in this specimen are distinctly shown, the surface being well preserved. No punctate striation, transverse to the axis, can be discovered. Aperture involved in matrix; anterior extremity apparently oval rather than circular.

Relations and Distribution.—Nothing further can be said on this score than what is applicable to species distinguished by a general convexity of the whorl, such as may be noted in the descriptions of *Chemnitzia Clytia*, D'Orb., *Ch. athleta*, D'Orb., and some other forms noted by the author of the Terrains Jurassiques. Not any of these are identified by Brauns in the Corallian of North Germany, and in our Yorkshire beds they are so rare that the specimen figured is the only one well preserved which has come under my notice.

It should be stated, however, that there are specimens in the Coral Rag of Ayton and Brompton, having a spiral angle as low as 16°, which clearly belong to the convex-whorled group, and are very like the figure of *Ch. Clytia*, D'Orb.[1]

11.—"Phasianella" striata, Sow., 1814. Young specimens. Plate XIV. Figs. 1*a*, 1*b*.

Melania striata, Sowerby, 1814, Min. Conch. p. 101, pl. 47.

Bibliography, etc.—The original figure was made up of two specimens: the lower part from the Coral Rag of Goatacre, the upper from a totally different formation at Lymington in Somersetshire, the combined cast being about 8 inches in height. The thinness of the shell is such that, although it often leaves its mark on the cast, whereby we recognize the transverse bands, it is seldom that any portion has been preserved. Owing to this circumstance it is difficult to say whether the casts so abundant in the *Humphresianus*-zone of the Inferior Oolite at Cheltenham can be deemed specifically identical or otherwise with this very characteristic Corallian species. A similar form also occurs in the *Humphresianus*-zone of the Inferior

[1] *Chemnitzia melanioides*, Phillips.—I have hitherto failed to identify this figure with any fossil known to me. The original should be at York, but I have not had the good fortune to see it.

Oolite at Scarborough (Scarborough Limestone), and this was referred by Morris and Lycett (p. 118, pl. xv. fig. 19) to Sowerby's species. Some of the specimens from the Cheltenham district are marked *Ph. Sœmanni*, Oppel, and *P. Oppeli*, Wright MS., in the Jermyn Street Museum. Young and Bird, edition of 1822, give a very recognizable figure (pl. xi. fig. 9) of one of the more obese forms, and D'Orbigny's figures (Ter. Jurass., plates 324 and 325) are excellent. The latter author (*op. cit.* vol. ii. p. 323) speaks of the species as occurring on two stages—in the Callovian at Pizieu, and in the Oxfordian at many places both in France and England. From this fact we may infer that D'Orbigny's Oxfordian must include much of our Corallian.

Description.—Fig. 1*a*. Specimen (cast) from the Coralline Oolite of Ness (my Collection). The spiral angle rather exceeds 40° (D'Orbigny's limit is 30°—44°). The whorls, five in number, increase under a regular angle, and are tumid above, but become more depressed below. The last whorl rather exceeds the whole of the spire in height, and exhibits on a larger scale the characters of the other whorls; it is not either rounded off or bevelled off, but presents an angular outline, which is characteristic of all stages of the species, though it is lost in old and very large specimens. The cast is too much worn to show the usual traces of the thin striated shell.

Fig. 1*b*.—Specimen from the Corallian of Yorkshire (Leckenby Collection.)

Length (restored)	28 millimètres.
Width	16 ,,
Length of last whorl to entire shell	50 : 100
Spiral angle	42°.

The shell of this specimen, which may be taken to represent the next size of the ordinary form of *Ph. striata*, has its lower whorls preserved in calcite.

The whorls of the spire are tumid, and the shell substance thick, the transverse banding characteristic of the species appearing on the surface somewhat faintly. The body-whorl is also tumid, but not disproportionately: its shell substance would seem to have been less thick, and the transverse banding shows out better where the shell is thinner. It is probable that the banded structure pervades the entire thickness of the shell, as it is so well shown upon casts. The bands in the base of the body-whorl are wider and more prominent.

Relations and Distribution. — As previously indicated, opinions differ as to whether this great shell is really the same as the one in the Inferior Oolite. It is, or its closely allied congeners are, amazingly abundant on certain horizons in the Jurassic rocks, whilst totally absent from others. Thus there is no representative of the group in the Great Oolite of Minchinhampton, where there are so many Gasteropods, nor yet in the Cornbrash of Yorkshire. It is immensely abundant on certain lines in the Yorkshire Corallian beds, not so low, however, as the Lower Coral Rag of Hackness. Very large specimens occur in the shelly beds which succeed the Middle Calcareous Grit in parts of the Tabular Range, and it is again extremely abundant at the base of the Coral Rag of the Scarborough district, and in parts of the Coralline Oolite of Malton.

12.—"PHASIANELLA" STRIATA, Sow.; var. BARTONENSIS. Plate XIV. Fig. 2, back and front.

Description.—Specimen from the Coral Rag between Slingsby and Barton (my Collection).

Length (restored)	81 millimètres.
Width	31 ,,
Length of body-whorl to entire shell	38 : 100.
Spiral angle	30°.

The chief differences noticeable between this variety and the ordinary *Ph. striata* are, *firstly*, that the spiral angle is less open than in the specimens of *Ph. striata* from the Corallian rocks of Yorkshire, where it usually amounts to 40°. *Secondly*, the upper part of the whorl is less tumid, whilst the lower part exhibits a sharp turn in, which accentuates the sutural excavation. This peculiarity seems to arise from each whorl being less completely covered by its successor than is the case in the ordinary form. *Thirdly*, the aperture is inclined to be subquadrate instead of oval; but as the outer lip is not quite perfect, we must not feel too sure of this. The shell also would seem to be rather thicker.

Relations and Distribution.—This form does not seem to have been noticed generally, and we may conclude that it is rare. Deslongchamps has figured[1] a variety of Sowerby's species from the Argile d'Honfleur (Kimmeridge Clay) at Villerville, in which the spiral angle and general characters appear much the same as in the Barton specimen; hence, the horizon of these elongated varieties may be higher than that of the more ordinary forms. In Yorkshire I have found one or two casts of the var. *Bartonensis* at different localities in the Coral Rag of the Howardians, where the more regular form is far from being common. Neither in England nor in the Boulonnais has any member of this *striata* group been recorded from more recent beds of Jurassic age.

13.—PSEUDOMELANIA GRACILIS, sp.n. Plate XIV. Figs. 3*a*. and 3*b*.

It seems somewhat strange to go in search of a new name for such a plain shell as this—yet its unornamented character renders it all the more difficult of identification. *Buccinum sublineatum*, Rœm. (N. O. G. p. 139, pl. xi. fig. 22), is something like; and the reproduction of this species by D'Orbigny as a *Chemnitzia* (Terr. Jurass. vol. ii. p. 56, pl. 241, fig. 6) from the Oxfordian Oolite of Trouville is still more so, but that author gives a spiral angle of no more than 25°—which is hardly enough for our shell. Von Seebach (Han. Jur. pl. vii. fig. 2) has a figure of *Chemnitzia striatella*, identified by Brauns with Rœmer's species from the Lower Kimmeridge of North Germany, which has much less resemblance. There are of course plenty of other figures and descriptions which nearly fit, but none exactly. In this case, therefore, a new species might do less harm than an incorrect identification.

[1] Mem. Soc. Linn. Norm. tom. vii. pl. 12, fig. 4.

Description.—Fig. 3a. Specimen from the Coral Rag of Ayton (Leckenby Collection).

Length	27 millimètres.
Length of body-whorl to entire shell..........	48 : 100.
Spiral angle	33°.

Shell conical, smooth, not umbilicated, spire composed of nine whorls, very regular in outline, scarcely convex, and devoid of visible ornament. Sutures close, not very marked. Body-whorl about equal in height to the entire length of the shell. Outer lip very straight, which gives the mouth an angular appearance. Shell substance thick.

Fig. 3b.—Specimen from the Coral Rag of Brompton (Strickland Collection). Restored it would have a length of about 33 mm., with a spiral angle of 33°, and the body-whorl is a little higher in proportion to the entire shell than in the other specimen. Only four whorls remain. It would appear to represent a larger individual of the same species as the last. The shell substance is very thick.

Relations and Distribution.—The flatness of the whorls, and the straightness of the outer lip, in addition to the spiral angle, may serve to distinguish this species from any other *Pseudomelania* in Yorkshire of like age. The two specimens figured are the only ones known to me.

14.—PSEUDOMELANIA BUVIGNIERI, auctorum. Plate XIV. Figs. 4*a.* and 4*b.*

Bibliography, etc.—Shells more or less answering to the description of the two here figured were recorded in the lists of the Corallian Rocks of England, and in the Table of Fossils of the Corallian Rocks of Yorkshire, as *Ps. Buvignieri,* D'Orbigny (Terr. Jur. vol. ii. p. 325, pl. 325, figs. 3—5). D'Orbigny's species is, however, only 10 mm. long, and in the description the author gives the length as one of the characteristic features. In some collections similar forms are referred to *Phasianella elegans,* M. and L. (Gr. Ool. Moll. p. 74, pl. xi. figs. 27, 27*a.*), and the larger of the two specimens figured has considerable resemblance, though the differences are not difficult to point out. Altogether the name now adopted must be regarded to a certain extent as provisional, and even the grouping of 4*a* and 4*b* under one denomination as more or less open to question.

Description.—Fig. 4a. Specimen from the Coralline Oolite of Nawton (my Collection).

Length (restored).............................	27 millimètres.
Length of body-whorl to entire shell..........	52 : 100.
Spiral angle	42°.

Shell short, conical, smooth, not umbilicated. Whorls probably about eight in number, increasing regularly under an angle of 42°, convex, perfectly smooth and devoid of ornament, sutures distinct. Body-whorl tumid and in height very slightly exceeding the rest of the spire. Mouth very oval and regular with a slight callosity on the inner side.

Fig. 4b.—Specimen from the Coral Rag of Brompton (Strickland Collection).

Shell conical, short, smooth, not umbilicated. Whorls about seven in number, increasing under a regular angle of 38°. The length restored would be about 46 mm., with a body-whorl not quite equal in height to the entire spire. The whorls of the spire are convex, rather high and perfectly smooth. Body-whorl scarcely tumid, very round, and free from angularity at the base. Aperture widely oval. The front of the upper whorls is involved in matrix.

Relations and Distribution.—These very average forms have near relatives in several of the Jurassic beds as low down as the Lias. *Melania bulimoides*, Desl., from the Coral Rag (Oxfordian according to D'Orbigny),[1] of Trouville, is not very far from Fig. 4*a*, whilst there can be little doubt that Fig. 4*b* is the Corallian representative of the *Ph. elegans* of Minchinhampton. In the Great Oolite shell the whorls are more tumid, and the sutures more deeply cut, giving a slightly turrited appearance. Fig. 4*b* is a unique specimen; should more be discovered, it might be almost worth describing as a species under the name of *Pseudomelania sub-elegans*. The other form is also comparatively rare.

15.—Pseudomelania, sp. Plate XIV. Fig. 5.

As this is the only specimen known to me, it is not deemed advisable to give any specific name.

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

Length (restored)	45 millimètres.
Width	17 ,,
Length of last whorl to entire shell	40 : 100.
Spiral angle	31°.

Shell conical, slightly elongated, smooth, without ornament. The whorls would appear to increase regularly under an angle of about 30°. They are convex, with a tendency to slope in the upper part of the whorl. This slope has the effect of accentuating the sutures, and gives a character to the shell, which might perhaps have been placed under *Chemnitzia*, if the generic distinction is worth preserving. The aperture is very ovate, the outer lip coming out with a bold sweep; the anterior portion is slightly broken away. Columellar lip only moderately curved, and rather thin. No umbilicus, but a faint groove at the junction of the inner lip with the columella.

16.—Pseudomelania Leymeriei, D'Archiac, 1843. Dwarf. Plate XIV. Fig. 6.

Phasianella Leymeriei, D'Archiac, 1843, Mém. Soc. Géol. Fr. tom. v. t. 28, fig. 12.
———————— Morris and Lycett, Moll. of Gt. Ool. p. 74, pl. xii. figs. 31, 31*a*, 32.

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

Length (restored)	15 millimètres.
Width	8·5 ,,
Length of last whorl to entire shell	63 : 100.
Spiral angle	56°.

[1] *op. cit.* pl. xii. fig. 15.

Shell short, conical, smooth, not umbilicated. The whorls are five or six in number, convex, and have a tendency to increase under a high angle with a nearly uniform slope and but little tabulation. Body-whorl considerably higher than the rest of the spire and moderately ventricose. The condition of the specimen does not admit of a more detailed description.

Relations, etc.—This is unfortunately the only specimen I can obtain. It is one of the very few Univalves of the lower beds, and a more exact determination would therefore be desirable. Some might regard it as a small *Natica*, like *N. punctura*, Bean, for instance. To me the shell appears too evenly conical for a *Natica*, and though so small it very much resembles specimens from Minchinhampton referred as above.

Genus Cerithium, Adanson, 1757.

There are no more than three species which can be said to be common, viz. *C. muricatum*, Sow., *C. limæforme*, Rœm., and *C. inornatum*, Buv., as identified. The number of the remainder would vary according to the views taken respecting varieties, but under any circumstances seven or eight would be the limit. This is about the number given by Morris and Lycett for the Great Oolite *Cerithia*, but the species in that formation are for the most part very different to those of the Yorkshire Corallian.

In Germany, according to the older authors on the Jurassic rocks, the muricated *Cerithia* are represented by *C. costellatum*,[1] Münst., Lias; *C. muricato-costatum*, Münst., Lower Oolites; *C. nodoso-costatum*, Münst.; *C. septemplicatum*, Rœmer, Upper Coral Rag. The granulated forms are *C. quadricinctum*, Münst., Lower Oolites, and *C. limæforme*, Rœmer, Upper Coral Rag. Since those days Buvignier[2] has described and most elaborately figured twenty-nine species of *Cerithia*, of which fourteen are from the Coral Rag of the Meuse, with one exception, all being claimed by him as new.

De Loriol and Pellat[3] also have made a handsome addition to the lists in respect of this genus, and several of their new species are of Corallian age. Some indeed look like old friends we have seen before under other denominations.

17.—Cerithium muricatum, Sow., 1825. Pl. XIV. Fig. 7.

Turritella muricata, Sowerby, 1825, Min. Conch. vol. v. p. 159, pl. 499, figs. 1 and 2.
Ibid, 1829, Phillips's Geol. of Yorkshire, t. 4, fig. 8.
Cerithium Struckmanni, Loriol, 1873, Et. Supr. Jurass. vol. i. p. 75, pl. vii. figs. 25-27.

Bibliography, etc.—Sowerby's original specimens are from Steeple Ashton. His fig. 1 is a characteristic block full of this very common form, along with the well-known "*Turbo*" *muricatus*. Fig. 2 is a good representation of a single specimen of the type which is so plentiful in the shell-beds of the Coralline Oolite of the southern counties. Being excessively common, and having probably a great range, this shell has naturally attracted the attention of many writers

[1] See Goldfuss, Petrefacta, div. v. p. 29, pl. 143.
[2] Stat. Géol. de la Meuse.
[3] Et. Supr. Jurass. de Boulogne.

on palæontology, and its *aliases* are proportionably numerous. There is probably, as we shall see presently, some difference in *Cerithium Russiense*, D'Orb. (Prodr., ét. 13); but I altogether fail to see the justification for the *C. Struckmanni* of De Loriol, still less for its adoption by Brauns as the representative of the species in North Germany. This seems to me a case where lists require considerable purgation, and it serves to illustrate at the same time the sort of information which a young geologist, not versed in the intricacies of synonymy, may derive from tables of fossils.

Description.—Specimen from the base of the Coralline Oolite, Pickering (my Collection).

Length (restored)	20 millimètres.
Width	6 ,,
Spiral angle	19°.

Shell elongated, turrited, sharply pointed. Whorls probably fourteen in number, flat, sloping slightly, but increasing by steps; sutures strongly marked. The ornaments are conspicuous, and consist of five transverse (spiral) ribs, decussating with very numerous longitudinal ribs, which latter are nearly, but not always, in line in each separate whorl. The network or interlacing thus produced is rather fine; the intersections are drawn out transversely, so that the nodes are elongated, but not spiny. The general aspect of the ornamentation is closely set and regular. The transverse ribbing is continued over the base of the body-whorl, but without decussation. The aperture is involved in matrix.

Relations and Distribution.—It will readily be believed that so common a shell must have relations in the older beds, but the whole subject is so confused that I cannot venture to grapple with it at present, though I think that this is a higher form than the next, to which it is closely related. At Pickering both occur together, and, unless in a fairly good state of preservation, would doubtless receive the same designation.

It is noteworthy that, according to De Loriol and Pellat,[1] both this and the succeeding species are found together at Viel St.-Remy—I presume in the ferruginous oolite. I have myself received it from the corresponding bed of the Ardennes. It is quoted as *C. Struckmanni* from the Séquanien of Boulogne. If there is any difference, De Loriol's shell has a slightly wider base.

As before observed, this is the common *Cerithium* of the Corallian beds throughout England, but in Yorkshire it never ascends into the Coral Rag. The shell-beds of the Coralline Oolite are its chief repository, though it, or the next species, occurs in the Lower Calcareous Grit.

18.—Cerithium Russiense, D'Orbigny, 1845. Plate XIV. Figs. 8*a*, *b*, *c*.

Cerithium Russiense, D'Orbigny, 1845, in Murchison, Verneuil and Keyserling, 2, p. 453, pl. 38, fig. 9.

Bibliography, etc.—D'Orbigny, in his Prodrome (vol. i. p. 357),

[1] *op. cit.* p. 76.

classes the preceding species with this one. I have not seen the original description, but quote from De Loriol and Pellat, who point out the differences.

Description.—Fig. 8*a*. Specimen from the Coralline Oolite of Pickering, amongst the *Trigonia*-beds (my Collection).

Length	25 millimètres.
Width	7 ,,
Spiral angle	22°.

Shell elongated, turrited, sharply pointed. Whorls about fifteen in number, increasing under a regular angle, and separated by well-marked sutures. They are nearly flat and distinguished by very bold ornaments. These latter consist of broad transverse ribs, four in number, on all the whorls except the last, and they decussate with very stout longitudinal ribs, which on the penultimate whorl are about sixteen in number. These ribs have a considerable inclination from the axis of the spire, and are sharply separated by the suture from those in the adjoining whorl, with which they do not always correspond. The intersection of the two systems of ribbing gives rise to a set of spiny nodes; the upper one in each whorl is usually the most prominent and spiny. The last whorl is slightly less flat than the others; it has the same character of ornament, though in a less marked degree. The longitudinal ribbing is not continued in the base of the whorl, which, however, is ribbed transversely. Aperture imperfectly preserved.

Fig. 8*b* represents a variety of this species from the same place, but in a different state of preservation. Originally this shell seems to have been more turrited than Fig. 8*a*. The points of the spines have been ground down.

Fig. 8*c* represents a variety where the longitudinal ribs are not developed in the under whorls.

Relations and Distribution.—There is a considerable difference in all three of these specimens, but they agree in having only *four* spiral ridges or ribs. Fig. 8*b* is strongly turrited; Figs. 8*a* and 8*c* less so. Not known to me in Yorkshire above the base of the Coralline Oolite at Pickering. This form occurs in the Lower Calcareous Grit.

EXPLANATION OF PLATE XIII.

Fig. 1*a*. *Chemnitzia Heddingtonensis*, Sow. Base of Coralline Oolite, Pickering. Back view. My Collection.

,, 1*b*. ,, ,, Another specimen to show the aperture. Coralline Oolite of Ness. My Collection.

,, 1*c*. ,, ,, Young specimen. Shell with punctate structure. Coralline Oolite of Malton. My Collection.

,, 1*d*. ,, ,, Younger specimen. Coralline Oolite of Ampleforth Beacon. My Collection.

,, 2. ,, *Pollux*, D'Orb. Coral Rag of Langton Wold. My Collection.

,, 3. ,, *Langtonensis*, Bl. & H.; Coral Rag of Langton Wold. My Collection.

,, 4. ,, cf. *corallina*, D'Orb. Probably from the Coral Rag of Langton Wold. Leckenby Collection.

EXPLANATION OF PLATE XIV.

FIG. 1*a*. "*Phasianella*" *striata*, Sow. Very young specimen. Coralline Oolite of Ness. My Collection.
,, 1*b*. ,, ,, Young specimen. Probably from the Coral Rag of Ayton. Leckenby Collection.
,, 2. ,, ,, var. *Bartonensis*. Coral Rag near Barton. Back and front. My Collection.
,, 3*a*. *Pseudomelania gracilis*, sp. n. Coral Rag of Ayton. Back and front. Leckenby Collection.
,, 3*b*. ,, ,, Coral Rag of Brompton. Back and front. Strickland Collection.
,, 4*a*. ,, *Buvignieri*, auct. Coral Rag of Nawton. Back and front. My Collection.
,, 4*b*. ,, ,, Coral Rag of Brompton. Back and front. Strickland Collection.
,, 5. ,, *species*, Coral Rag of Brompton. Back and front. My Collection.
,, 6. ,, *Leymeriei*, D'Arch. Passage-beds of Lower Calcareous Grit. Back and front. My Collection.
,, 7. *Cerithium muricatum*, Sow. Base of Coralline Oolite, Pickering. Front view and two whorls enlarged. My Collection.
,, 8*a*, *b*, *c*. ,, *Russiense*, D'Orb. Base of Coralline Oolite, Pickering. Three different specimens, with portions enlarged. My Collection.

(*To be continued.*)

III.—NOTE ON THE PEBBLES IN THE BUNTER BEDS OF STAFFORDSHIRE.

By Prof. T. G. BONNEY, M.A., F.R.S., F.G.S.

FOR many years past I have been familiar with the Trias of Staffordshire, but of late I have been noticing more carefully, during my occasional visits to that county, the pebbles in the Bunter, in the hope of being able to identify the parent rocks from which they have been derived. It has already been regarded as almost certain that many of them have a northern origin: and with this idea in view I observed last summer the lithological character of the quartzites near Loch Maree. Although the results at which I have arrived are very incomplete, I think more good will be done by publishing them than by waiting, because, as it seems to me, they settle one or two points of importance, and because a question, like that of the origin of the pebbles in a deposit so widely spread as the Bunter, is one which can be better determined by a number of observers living in different localities than by any one person, especially if, like myself, he has but little time to spare for the investigation. If, however, I can show that one or two points may be regarded as fairly certain, it will very much facilitate the work of such observers. This work, the careful scrutiny of the contents of conglomerates, is one of more importance than may at first sight appear, because a rock fragment no less, and sometimes more, than a fossil records certain facts in the physical geography of the deposit in which it is found.

The following notes relate chiefly to the northern edge of Cannock Chase, within two or three miles of the town of Rugeley. The majority of the pebbles in the Bunter beds of this district are quartzites. Most of them clearly belong to one variety of this rock.

They seem to consist almost wholly of grains of quartz, which are very closely agglutinated, so as to give an unusually compact texture to the rock, and be with difficulty visible to the eye. The fracture is clean and subconchoidal, and the outside of the pebble quite smooth. The colour varies; there are many shades of grey, from almost white to a sort of dark purplish, and occasionally a peculiar liver colour. Pebbles also of white vein quartz are common, with hard grits and quartzites rather different from the above, and other rocks in small numbers, some of which will presently be noticed.

Professor Hull pointed out some years since that the quartzite pebbles must have been derived from Scotland,[1] and it was a natural inference to refer them to the great mass of that rock which is so well developed on or near to the north-western coast. During my visit to Ross-shire last summer, I examined the quartzite in the vicinity of Loch Maree, and saw either in boulders or *in situ* most of the varieties which occur in Staffordshire, so far as the unaided eye could identify them. The liver-coloured quartzite alone was wanting. I had three microscopic sections prepared from Ross-shire quartzites (white and grey), and compared them with two from Bunter pebbles (grey and liver-coloured) already in my collection. The former consist almost wholly of grains of quartz, agglutinated together as is usual in highly-altered quartzites. These grains often contain many very minute inclosures, some apparently exceedingly small cavities, others specks of opacite, ferrite, etc. They frequently have a somewhat linear arrangement. There are also present occasional fragments of a very fine-grained quartzite, and of felspar, and specks of a greenish micaceous, chloritic or hornblendic mineral. The felspar is often banded, some with a wavy or cross-hatched structure much resembling that of microcline. All the above also occur in the Torridon sandstone; and the quartz and the felspar of the Hebridean gneiss, from which its materials have undoubtedly been derived, frequently exhibit these characteristics. Now in the slides from the Bunter conglomerate we find a similar structure; the quartz with similar inclosures, occasional grains of similar felspar: of a fine quartzite, and specks of the same greenish mineral. I can see no distinction whatever between the slides from the grey Bunter pebble and those from Ross-shire, and that from the liver-coloured pebble has only varietal differences.

Further, it occurred to me when in Ross-shire that if the Bunter conglomerate were in great part derived from North-west Scotland, one might hope to find in it specimens of the harder varieties of the Torridon sandstone. On my next visit to Staffordshire I found that pebbles bearing a close resemblance to it, though with the felspar much decomposed, were far from uncommon. Two of the best preserved of these have been cut for microscopic examination. Now the structure of the Torridon sandstone is rather peculiar. As already described in my paper on the vicinity of Loch Maree,[2] I found in it quartz grains like those named above, felspar, "orthoclase, microcline, and plagioclase (? oligoclase)," fragments of fine quartzite

[1] Mem. Geol. Survey, Permian and Trias of Midland Counties, p. 60.
[2] Q.J.G.S. vol. xxxv. p. 98.

and schisty or slaty rock. In the pebbles from the Bunter I find quartz with the same inclosures, even to the occasional presence of small acicular prisms of a pale greenish mineral (which I cannot venture to name), felspar, which, though much decomposed, still shows resemblance to the above, and occasional bits of rather similar altered rocks. I think, therefore, I am justified in identifying these pebbles with the Torridon sandstone, seeing that it is a rock which even macroscopically is of a marked and exceptional character. This additional evidence proves that those authors who considered the Bunter pebbles to have been largely derived from the rocks in the North-west of Scotland were right.

There is, however (as I have for some time suspected), a second quartzite represented in the Bunter pebble-bed. This is very variable in appearance, being sometimes coarse, sometimes fine. It is more granular and altogether less compact in texture, being often rather a hard grit than a true quartzite, and frequently contains many specks of decomposed felspar, resembling more the quartzites of Budleigh Salterton, the Lickey and Hartshill. To this rock belong, so far as I have seen them, the pebbles collected by Mr. Percival and Mr. Jennings.[1] Specimens of this are not unfrequent on Cannock Chase, and appear to me to become more common in the district about Birmingham and Bromsgrove. I have already found two or three specimens of this rock from the neighbourhood of Rugeley containing numerous fossils, while the only trace of organisms which I have been able to discover in the other rocks have been two instances of obscure annelid tubes. One contains an *Orthis*, which struck me as resembling *O. redux*; so, as usual in a palæontological difficulty, I trespassed upon the kindness of Mr. Etheridge, who thus writes: "The *Orthis* is *O. redux*, var. *Budleighensis*, Dav. This shell occurs both at Budleigh Salterton and Gorran Haven in Cornwall, somewhat abundant at both places. I should not be able to distinguish the Cornish specimens from those of Budleigh or your specimen in the pebble from Rugeley. Lithologically and zoologically they are identical. So also with the Lickey specimens, from which place, indeed, your pebble might have been derived. In the redder and coarser sandstone or quartzite there is a *Rhynchonella* sp.? and probably *O. calligramma*, and casts of the ossiculæ of a *Glyptocrinus*. These are all the organisms I can make out."

I have always doubted whether the Lickey rock was likely to have contributed to the Bunter pebbles, chiefly because I could not identify exactly any of them with the Lickey rock as known to me; but the other day Mr. Etheridge showed me a specimen from Longwood,[2] on the S.W. side of the range (where I had never been); which contained several fossils, as above, and was exactly like this Bunter rock. As it is, from physical considerations, almost impossible that Cornish pebbles can have made their way hither, and as these less altered fossiliferous quartzites certainly seem more abundant on the Worcestershire side of the county, I agree with Mr. Etheridge

[1] Geol. Mag. Dec. II. Vol. V. p 239, 333. Cf. Brodie, Q.J.G.S. vol. xxiii. p. 210.
[2] Near Dubury Hill. The slab also contains *Petraia bina* and a *Meristella*.

that we may refer them to the range of the Lickey—thus they are (probably) of Llandovery age.[1]

Besides the above rocks, I have lately found several specimens of felstone: One, a reddish compact variety, with distinct traces of fluidal structure and small occasional crystals of quartz and felspar; another, a rather similar but paler-coloured rock, with specks of a dark mineral; a third, with larger crystals of pink felspar; a fourth, with fewer but larger crystals of white felspar; and a fifth, with a dark ground-mass and crystals of orthoclase, inclosing black microliths. Some of these resemble rocks which I have obtained from Scotland, but I pass these by for the present with a simple mention.

I have also found pebbles of flinty rocks, akin to Lydian stone and porcellanite, a dark schisty rock, with minute microliths of a black mineral (? tourmaline, of which mineral I have found needles in a quartz pebble), limestones and chert with casts of Crinoid stems. The last two are probably from the Carboniferous Limestone, from which formation also the galena may have come, which has occurred in the lower part of the pebble-bed.[2]

Of these, and other inmates of the conglomerate, I hope in the course of a year or two to gather additional information. In conclusion, I will only venture on one remark with regard to the physical history of the Bunter, which, though probably not novel, I do not remember to have seen in print. It is now very commonly held that the Trias, in accordance with Prof. Ramsay's view, was formed in an inland sea or lake. So far as regards the Keuper, I think this in the highest degree probable, but not as regards the Bunter. Its frequent false-bedding, the number and size of its pebbles, seem to point to the action of strong currents,[3] such as would only occur in an open sea or in the delta of a large river. The resemblance to the English Bunter of some of the red beds of the Lower Carboniferous group of Scotland (notably in Brodick Bay, Arran, where the same quartzites abound,[4] is most remarkable. The one is considered to be a fluviatile deposit, and why not the other? Thus, the Bunter beds of Central and Northern England may represent the deltas of two large streams descending respectively from the north-west and north-east, and receiving tributaries from land on either side. The Lower Trias of Southern England would be produced by a stream or streams from the Palæozoic land to west and south. Thus, in the latter district, there may have been a precursor of the Great Wealden river, just as there seems to have been in North Germany, and I am by no means sure, that even in the former district we have not some indication in Jurassic times of the rivers of the preceding period.

[1] Mr. S. G. Percival's collection of pebbles from the Moseley district (in the Jermyn Street Museum) contains the following fossils: *Orthoceras ? Cleidophorus amygdalis*, *Orthis redux*, var. *Budleighensis*, *Stricklandinia lyrata*, *Spirifera disjuncta*, *Glyptocrinus*, *Petraia (bina ?)*.

[2] Molyneux, Brit. Assoc. Rep. 1872 (Brighton), Tr. of Sect. p. 116.

[3] The average Staffordshire pebbles would require a current of about three miles an hour to sweep them along. Large pebbles (up to 6 or 8 inches in diameter) are by no means infrequent.

[4] Geol. Mag. Dec. II. Vol. V. p. 428.

IV.—The Mammoth in Siberia.

By Henry H. Howorth, F.S.A.

THE overlapping of the sciences is made the subject of much rhetorical writing now-a-days, and its appreciation is one of the most prominent signs of the modern development of the doctrine of Continuity which has been so fruitful in the Philosophy of Discovery. The boundary-line which once separated the geologist and ethnologist has in consequence of this development entirely disappeared, and every one now admits as a postulate that between the two sciences there is a stretch of neutral ground belonging to neither exclusively, and where the students of each must of necessity reap if their harvest is to be complete. Not only so, but it is beginning to be seen that the methods and the directions of the arguments in each science being more or less different—the one partaking much more of the historical, and the other of the experimental method—that it is well that where they overlap the results of each should be closely compared, and thus not only secure a double modicum of certitude, but also suggest fresh veins of untried material where we may put in our mattock with renewed hope of solving some apparently hopeless problems.

The Mammoth presents very fairly a focus about which we may group that congeries of difficulties which is the common property of the ethnologist and the geologist. As a student of ethnology who have done, I trust, yeoman's service in some of its walks, and have, like all the brotherhood, cast many an anxious glance towards that Sorbonian bog where the puzzle of the origin of our race lies buried, and as a student whose special subject has been the nomadic races of Central and Northern Asia, I have accumulated some materials which I believe may throw a little light on that problem, and perhaps also on corresponding problems which are presented to the geologist in the same area. The last leaf of the geological book and the first one of the ethnological book being, in fact, the same document, we cannot illustrate the one without at the same time throwing light on the other. I preface the remarks I mean to make with these observations, because the methods which I shall use in approaching the problem will not be strictly geological ones, and I therefore have to claim the indulgence of your readers if, in presenting them my sheaves, they complain of the way in which the straw has been cut and the bundles have been tied. Whether there be any thing else than straw in what I have to offer is not for me to say.

I shall begin, as is the custom with most of my craft, with a small etymological excursus, and then limit this paper by bringing together some forgotten and obscure archæological facts relating to the Mammoth, which are not uninteresting in view of some current discussions, and remit more purely geological matters for another number.

The word Mammoth is clearly a corruption of the Arabic word Behemoth, a great beast, the letters *b* and *m* being interchangeable, as is well known, in many Arabic dialects. One of the earliest notices of the Mammoth, if not the earliest, is that of Father Avril, who travelled to Russia in 1685, etc. He calls it always Behemot (Avril's Travels, 175–177).

Witzen, the famous Dutch writer, was, I believe, the first European writer who used the term Mammoth. He doubtless imported the term from Russia. Strahlenberg, who wrote his account of Siberia, after a residence there of many years, in the beginning of the eighteenth century, says, as to the name Mammoth, "It doubtless had its origin from the Hebrew and Arabic; this word denoting Behemot of which Job speaks (xl. chapter), and which the Arabs pronounce Mehemot. . . . It is certain the Arabs brought the word into Great Tartary; for the Ostiaks near the river Oby call the Mammoth Khosar, and the Tartars call it Khir. And though the Arabian name of an Elephant is Fyhl, yet, if very large, they use the adjective Mehemodi to it; and these Arabs coming into Tartary, and finding there the relics of some monstrous great beasts, not certain of what kind they might be, they called these teeth Mehemot, which afterwards became a proper name among the Tartars, and by the Russians is corruptly pronounced Mammoth. . . . The Russian Mammoth certainly came from the word Behemot, in which opinion I am confirmed by the testimony of an ancient Russian priest, Gregory by name, father confessor to Princess Sophia, who was many years an exile in Siberia, from whom I was told that formerly the name for these bones in Siberia was not Mammoth, but Memoth, and that the Nurnan dialect had made that alteration" (Strahlenberg, *op. cit.* 402–3). These extracts will suffice to make clear what is indisputable, namely, that Mammoth is a mere corruption of the Arabic Behemoth or Mehemoth. The suggestion of an ingenious speculator of recent times, that it is derived from the word *ma*, meaning 'land' among the Fins and *mut*, which we are told in Esthonia means a 'mole,' is not for a moment tenable. The Esthonians live a long way from Siberia, and the name of the Mole among the eastern Ugrians is quite different.

The next question is, how comes it that the Arabs, who are now strangers to Siberia, should have given a name to the Mammoth which has become current in all the European languages? This leads into an archæological byeway, in which some out-of-the-way facts will, I trust, be found. Eginhard, the biographer of Charlemagne, tells us that his master received as a present from the great Khalif Harun-ar-Rashid, the horn of a Unicorn and the claw of a Griffon. These were long preserved in the Treasury at St. Denis, and are described in a work published at Paris in 1646, entitled Le Tresor Sacré de St. Denys, etc., to which my attention has been called by Mr. Franks. The Unicorn's horn was made the subject of an elaborate inquiry written at the Hague in 1646 (see Churchill's Travels, p. 387), in which it is said this horn was altogether like a similar one at Copenhagen, and that the Danes were of opinion that all those kind of horns found in Muscovy, Germany, Italy, and France, came from Denmark. The Danes sold these horns as Unicorns' horns. The one at St. Denis had the same root as the rest, hollow and worm-eaten at the end like a rotten tooth. "This being granted," says the old writer, "as it is really true, I will positively assert it to be a tooth fallen out of the jaw-bone of the same fish known in Iceland by the name of Narwhal, and that consequently it is no horn."

In regard to the Griffon's claw, it is a curious fact that a writer in the "Bulletin of the St. Petersburg Academy," in a paper on Griffons, who was not aware, apparently, of the existence of the St. Denis specimen, makes out that the so-called claws are nothing more than the horns of the fossil Rhinoceros. Upon this question Erman has a curious passage which I shall quote. He says, speaking of the narrative of Aristeas Proconesus, who made a journey into North-Eastern Europe: "The obscurest portion of his narrative, in which he tells us that the Arimasps, seeking metals in the extreme north of Europe, 'drew forth the gold from under the Griffons,' will be found to be at this moment literally true in one sense, if we only bear in mind the zoologically erroneous language used by all the inhabitants of the Siberian tundras. By comparing numbers of the bones of antediluvian pachyderms, which are thrown up in such quantities on the shores of the Polar sea, all these people have got so distinct a notion of a colossal bird, that the compressed and sword-shaped horns, for example, of the *Rhinoceros tichorhinus*, are never called, even among the Russian promnishleniks and merchants, by any other name than that of birds' claws. The indigenous tribes, however, and the Yukagirs in particular, go much further, for they conceive that they find the head of this mysterious bird in the peculiarly vaulted cranium of the same Rhinoceros, its quills in the leg bones of other pachyderms, of which they usually make their quivers; but as to the bird itself they plainly state that their forefathers saw it and fought wondrous battles with it: just as the mountain Samoyedes preserve to this day the tradition that the Mammoth still haunts the sea-shore, dwelling in the recesses of the mountains, and feeding on the dead." Erman goes on himself to suggest that this Northern tradition preserves the prototype of the Greek story of the Griffons, which is familiar to readers of Herodotus, and perhaps also of the Arab fable of the Roc. The gold sand is still found under the earth, and peat containing the fossil-remains of these Mammoth and Rhinoceros, so that the metal-finders of the Northern Ural did literally draw their gold from under the Griffons (*op. cit.* ii. 88 and 89). Again, "The nomade geologists at the Icy sea have arrived at the conclusion," he says, "that these bones are the talons or claws of gigantic birds, which were more ancient than the Yukagir tribe, and in former times fought with the latter for the possession of the tundras. I have already alluded to the way in which the Mythus of Northern Asia appears to have been transformed into the Greek fable of the Griffons. It is now propagated as credulously here in Yakutsk, as it formerly was by Aristeas and Herodotus. When I told them of the Rhinoceros, they said that they had often heard all about it, but that they always called the bones in question birds' claws, and saw no reason to change their custom" (id. 382). These passages enable us to predicate that the existence of the great pachyderms in Siberia was known in Europe before the time of Herodotus.

But to return to Harun-ar-Rashid. It is clear that the present he sent was that of a Narwhal's tusk, and the horn of a fossil Rhinoceros. There can be little doubt the former as well as the latter came from Siberia, for although it is not mentioned among the animals killed in the seas about Nova Zembla, Schmidt, in his recent journey on the Yenissei, saw such a Narwhal's tusk in the possession of a fur merchant named Satnikof at Dudmo, which had been detached and sent to him by a Samoyede. The presence of products of the Siberian tundras at Baghdad in the ninth century is surely a curious fact, of which we have other evidence. We are told by the early Arab geographers that Bolghari on the Volga was in the ninth and tenth centuries a famous mart of trade, and that there was an active traffic between it and Khuarezm or Khiva. They go on to say that in Bulgaria (used no doubt here as a general phrase) were often found fossil bones of an immense size. One traveller reports having seen a tooth two palms in width and four in length, and a skull resembling an Arab hut, and teeth like those of an elephant, white as snow, and weighing as much as 200 menns. These were transported to Khuarezm, and there sold at a great price. Out of them were made vases, and other objects, as was done from ivory (D'Ohsson, Abul Casim, 80). Samoyedes still carve out of Mammoths' teeth articles for their sledges and drinking cups. The Yukagirs use slices of Rhinoceros horn to strengthen their bows with (Ermann, ii. 86, and 382), and in the Christy collection may be seen elaborate figures and domestic objects, carved out of Mammoth ivory by the Yakuts. The Arabs, so far as we know, were the first people who developed this trade in fossil ivory, and we thus see how they should have given its recognized name to the Mammoth. Fossil ivory as a curiosity was doubtless known much earlier. Theophrastus, a contemporary of Alexander the Great, in a lost work on stones, as quoted by Pliny, mentioned ivory dug out of the ground.

Having seen how early these Siberian deposits were known in Europe, it will not surprise us to learn that they were known also in early times in China. When Tilesius wrote his famous memoir on the Mammoth found by Adams, he was supplied by Klaproth with some curious information from Chinese sources. He says, when he was at Kiachtu on the Chinese frontier in 1806, he learnt from several Chinese that Mammoths' bones were known to them, and were called Tien shu ya, Teeth of the Mouse, Tien shu. On turning to a Manchu dictionary, he found the statement that the beast Fyn shu is only found in a cold region on the river Tutungian, and as far north as the frozen ocean. "The beast is like a mouse, but the size of an elephant. It shuns the light and lives in dark holes in the earth. Its bones are white like elephant ivory, are easily worked and have no fissures, and its flesh is of a cold nature and very wholesome."

The great natural history written in the sixteenth century, and entitled Bun zoo gan rom, says—"The beast Tien shu is mentioned in the ancient ceremonial written in the fourth century B.C., and is called Fyn shu and In shu, *i.e.* 'the self-concealing mouse.' It is found in holes in the ground, has the appearance of a mouse, but is as large as a buffalo. It has no tail, and is of a dark colour. Its strength is very great, and it digs itself holes in the ground in hilly and woody places. Another writer says the Fyn shu frequents only dark and solitary places, and dies when it sees the rays of the sun or moon. Its feet are very short in comparison with its bulk, so that it travels only with difficulty. Its tail is about a Chinese ell long, its eyes very small, and its neck crooked. It is also stupid and inert." In a great flood on the river Tan Shuan in 1571, many Fin shu appeared on the plain (Klaproth, note to Tilesius, Mems. St. Pet. Acad., 5th ser. vol. 5, pp. 409—411). These notices are very curious, since they show that the Chinese from early times not only were acquainted with fossil ivory from Siberia, but also knew of the occurrence there of Mammoths with their flesh and skin intact. The notion that they were still living underground has been very generally held by the indigenes of Siberia, and is a natural conclusion from the occurrence of the bodies in such a perfect state of preservation. I have already quoted the statement of Erman in this behalf. As early as 1731 we find Theodore de Hare, in his Dissertatio et Observationes Sacrarum Sylloge, writes—"de Mammuth seu Maman quod animal in regionibus septentrionalibus sub terra vivere referunt."

Father Avril, whose narrative I have already referred to, tells us, "The Russians have discovered a sort of ivory which is whiter and smoother than that which comes from India. Not," he says quaintly, "that they have any Elephants that furnish them with this commodity, but other amphibious animals which they call by the name of Behemot, which are usually found in the river Lena, or on the shores of the Tartarian sea. . . . Nor are elephants' teeth comparable to them, either for beauty or whiteness, besides that they have a peculiar property to staunch blood, being carried about a person subject to bleeding. The Persians and Turks, who buy them up, put a high value upon them, and prefer a scimitar or a dagger haft of this precious ivory before a handle of massy gold or silver." Again he says—"Nobody better understands the value of this ivory than they who first brought it into request, *considering how they venture their lives in attacking the creature that produces it, which is as big and as dangerous as a crocodile.*" From a Russian, whom Avril calls Mushim Pushkun, then Vowoda of Smolensko, and who, he says, had been a long time Intendant of the Government of Siberia, and knew the countries beyond the Obi well, he learnt "that at the mouth of the Lena there was a spacious island very well peopled, and which is no less considerable for hunting the Behemot, an amphibious animal, whose teeth are in great esteem. The inhabitants go frequently upon the side of the frozen sea to hunt this monster, and because it requires great labour and assiduity, they carry their families usually along with them" (Avril's Travels, i. 175—177). This notice is surely very curious, apart from its mere legends, in that it shows that the Bear Islands off the mouth of the Lena, still so famous for their deposits of Mammoth ivory, were known and resorted to for this very product in the seventeenth century.

Isbrand Ides, who travelled to China in 1692—95, tells us that among the Yakuts, Tunguses, and Ostiaks, it was reported that the Mammoth continually, or at least, by reason of the very hard frosts, mostly live under ground, where they go backwards and forwards, to confirm which, he says, they tell us that when one of these beasts is on the march and after he is past, the ground sinks in and makes a deep pit. They further believe, he adds, that if this animal comes near the surface of the frozen earth so as to smell or discern the air he immediately dies, whence the reason that several of them are found dead on the high banks of the river, where they unawares came out of the ground (Isbrand Ides' Travels, p. 26).

Strahlenberg, who wrote a few years later than Isbrand Ides, has a long article on Mammoths' bones, which he calls Mamatowa-Kost. He describes them as found at the mouths of the Obi, Yenissei, Lena, and other rivers. He says they generally could not be distinguished from ivory, except by being a little more yellow, caused by exposure to the air, "but sometimes they are of a brown colour like cocoa-nut shells, sometimes of a blackish blue, from the same cause. If the latter," he says, "are sawed into thin leaves and polished, one may observe upon them all sorts of figures of landscapes, trees, men, and beasts, which likewise proceeds from the decay of these teeth, caused by the air. . . . A great many of these teeth, which are white, are carried for sale to China." In discussing the kind of animal to which they belonged, he says—"That they were amphibious creatures, which is currently believed by the Siberian populace, I have always looked upon it to be a fable, nor have I ever met with two accounts of that matter which were of a piece" (*op. cit.* 402—404).

Bell, whose travels through Russia were published in 1788, says, that on the banks of the Obi, near Surgut, were found great quantities of fossil ivory. Some of it, he says, is also found on the banks of the Volga, and adds that the vulgar really imagine it is still living in the marshes underground, and that the Tartars tell many fables of its having been seen alive. The Commandant of Surgut had his entry ornamented with several very large tusks, of which he gave Bell one. Bell adds, he had been told by the Tartars in the Baraka that they had seen this creature at dawn of day near lakes and rivers, but on discovering them it always tumbled into the water and never appeared in the daytime. They described it as of the size of an elephant, with a monstrous large head and horns, with which he made his way in marshy places and under ground, where he concealed himself until night.

The notion has survived down to our own day. A meeting of the American Association for the Promotion of Science, a few days ago, was startled by news that Mammoths were still living, and that a Cossack had traced some to their haunts. This sensational news, I need not say, was not confirmed.

I notice that Mr. Skertchly, in his recent work on the Fen district, in which he has embodied so much valuable and interesting information, has gravely suggested that it is possible Mammoths may have been living quite recently in Siberia, grounding his argument on the above-quoted passage of Bell. I need not say that no Russian naturalist holds such a view, and that the popular legends are undoubtedly the natural outcome of the remains of these huge beasts being found under such curious conditions. The nature of these conditions, and the very interesting light they throw upon the most recent geological changes in the Northern hemisphere, we will discuss in another paper. Here it will have sufficed to collect the evidence showing how very early and widespread was the knowledge of the existence of the Mammoth, and to report some of the curious legends which the indigenes of Siberia have built up out of it.

V.—On the included Pebbles of the Upper Neocomian Sands of the South-East of England, especially those of the Upware and Potton Pebble Beds.[1]

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It has often appeared to me that in working out the ancient physical features of the earth in former periods of its history, too little attention has been given to one simple set of evidences which are of wide-spread occurrence, and, frequently, of very clear and decided meaning. I refer to the included rock-fragments of conglomeratic deposits. An appeal to these fragments would, I believe, often bring out clearly-written facts of no small value for the elucidation of the nature of ancient sea-margins, as compared with the much-involved palæontological evidences with which we are made so much more familiar.

Any particular rock exposed along the coast-line, or brought down to the sea by rivers, becomes more or less wide-spread along the shores and over the sea-bed as it is rolled into pebbles by the action of marine tides and currents, and scattered, it may be, by floating agents; and thus a series of pebbles in geological deposits shows the nature of the old sea-cliffs and neighbouring lands, and may serve to prove the original physical continuity of deposits now completely isolated.

Also a further interest attaches to these fragments as relics, scanty it may be, of those great masses of rock-formations which have been destroyed by the denudations of past ages.

Bearing in mind these interests, a series of pebbles has been gathered together by Prof. Hughes and Prof. Bonney, myself, and other geologists from the Neocomian Pebble beds of Upware (near Cambridge), Potton (Beds), and elsewhere, the results of which are embodied in the following account. To Professor Bonney I am par-

[1] Read before the Cambridge Philosophical Society, May 3, 1880.

ticularly indebted for the generous gift of his notes already written upon this subject.

The Potton and Upware Nodule beds have been already described by Professors Bonney and Seeley, Mr. Teall and Mr. Walker, and it is sufficient here to state that the deposit is a pebble bed or (when hardened by carbonate of lime or limonite) conglomerate, with a matrix of quartz sand, usually ferruginous, sometimes shelly and calcareous.

The great majority of the pebbles are the phosphatic nodules or 'coprolites' themselves, for the extraction of which the bed has been worked for the last ten or twelve years. These are of various ages, principally Upper Jurassic, but some of them are fragments of older Neocomians which were saturated with phosphate in the Upper Neocomian sea; none of them are proper to the bed itself. But besides these there is a scattering of other pebbles and rock-fragments, devoid of phosphate, which in the course of the workings are separated out by hand picking and thrown aside; and it is to these, as being but little known, though of peculiar interest, that we would now call particular attention. The following are found:—

1. Fragments of older Cretaceous rocks; mostly a dark-coloured, nearly black, ferruginous grit rock [1] occurring in irregular fragments often as much as three inches across. It contains numerous casts of Neocomian fossils, *Cucullæa donningtonensis* (MS.), *Cardium subhillanum*, etc. Rolled fragments of the Wealden *Endogenites* are also not infrequent in the Potton sands, and I have lately found it at Upware.

2. Pebbles from various Jurassic rocks, such as rolled fragments of limestone and chert, which have doubtless come from many of the Lower Oolites; argillaceous limestone, which may have been derived from concretions in Kimmeridge-clay or Oxford-clay, or even from the Lower Lias; and arenaceous rocks such as occur sometimes in the Lower Oolites of the Midlands.

One large pebble of pale yellow sandstone (3 inches diam.) has yielded a few fossils; namely, a mytiloid shell, and a transverse bivalve of doubtful affinities. The age of the rock is uncertain, but the balance of opinion would refer it to some part of the Jurassic period. Fragments of chert from these rocks are described below.

Besides these however, we find the following, obviously from a more ancient source:—

3. Small pebbles from about the size of a filbert downwards to a hempseed. These are abundant, so that often a dozen or more may be detected upon the face of a hand-lump of the phosphate rock. Quartz, apparently vein-quartz, is not uncommon; but the majority are angular or subangular fragments of hard, highly siliceous, fine-grained rocks, mostly dark coloured, many of which are simply chert, resembling that common in the Mountain Limestones of Derbyshire, the rest being highly indurated argillites (Lydian stone and

[1] This rock, and its fossils, are described more fully in another work on "The Fossils and Palæontological Affinities of the Neocomian Deposits of Upware and Brickhill," not yet published.

Hälleflinta). These Lydian stones are often banded by zones of different colour, texture, and hardness.

4. Larger pebbles (*i.e.* diameter more than an inch). These are much rarer, probably not more than one per cent. of the whole. The following have been collected at Potton, and may now be seen in the Woodwardian Museum.

a. Vein-quartz.—These are the most common, five or six of them being found to one of the rest. They are fairly well rounded, and, as a rule, do not exceed three inches in diameter. Traces of metallic ores are sometimes seen in them.

b. Fragments of hard *vein-breccia*; slaty and quartzose varieties, sometimes with geodic cavities.

c. Quartzite.—A very compact, hard, light-coloured variety, much resembling that from the Bunter conglomerates. These do not attain quite the size of the others.

d. An angular fragment of white saccharoidal quartzite measuring $4 \times 2\frac{1}{2} \times 2\frac{1}{2}$ inches, spotted with pale pink felspar crystals, and imperfectly laminated with layers of white mica.

e. One specimen only. A subangular, dark-coloured pebble of fine-grained, altered grit, with veiny patches of quartz.

f. Altered Grit.—A fine quartzo-felspathic grit of dark colour with small black specks—much resembling some of the grit in the Lower Cambrians of Wales. Two specimens found; the largest is a long pebble with the greatest diameter about $3\frac{1}{4}$ inches. Prof. Bonney states that in his specimen are several groups of minute belonites much resembling tourmaline.

g. Hard sandstone so indurated as to be almost a quartzite; light yellowish or whitish colour. These attain a somewhat greater size than (*a*); they have evidently been a good deal rolled, but are more irregular in shape. They appear identical with a rock common in the Cambridgeshire drift, which comes, I believe, from the Carboniferous series.

h. Indurated shale and Lydian stone.—Most of the fragments which have hitherto been designated Lydian stone are, I believe, more correctly chert. We have, however, met with some which appear properly to belong to this group of highly altered rocks.

i. Well-rounded oval pebbles of pale yellow, fine-grained argillaceous sandstone, sometimes micaceous and thinly laminated.

k. An irregular, oblong fragment of Cambrian or Silurian pale slate measuring $2\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{4}$ inches, its contours sharply angular and joint-hacked. It is made up of two distinct zones of rock:—(1), a pale olive-coloured soft shaly rock, really a slate, splitting at a high angle across the plane of the fossils; and (2), a half-inch of fine-grained felspathic, ash-like grit crowded with fossils. The specimen has now been broken up and I am able to identify from it—

Favosites fibrosus, var. *ramulosus*, Phillips.
Orthis elegantula, Dalman.
,, *testudinaria*, Dalman?
,, *biforata*, Schlotheim.
Strophomena, sp. (same as one from the Dalquorhan sandstones; *b*/404, of the Cambridge Catalogue).

l. Chert.—These fragments also not seldom exceed (*a*) in size, and are more distinctly subangular in form, being sometimes rude parallelopipeds with rounded sides and angles. Colour pale grey to almost black; also red and yellow. Several distinct types occur which prove to be of two different ages, namely, Carboniferous and Jurassic. The majority, I believe, have come from the Mountain Limestone, for we find in them numerous fragments of Crinoid ossicles (arm joints, and round-sectioned columns), minute shells, *Athyris*, Polyzoa, large sponge spicules and (?) *Chætetes*. These are white, grey, or black-coloured; opaque or translucent. But others, for the most part of reddish yellow colour and opaque, or but slightly translucent, are Jurassic, yielding muricated Cidaris spines fragments of shells and hinge of *Inoceramus*; *Pecten*, and other, Lamellibranchs.[1]

m. A pebble in the cabinet of Prof. Bonney, who thus describes it:—

"*Devitrified Pitchstone.*—This remarkable specimen was found by Miss Forster, of Newnham Hall. In form it was a flattened pebble rather compressed on one side, about $3\frac{3}{4}''$ by $3\frac{1}{4}''$ diameter, and nearly $1\frac{1}{2}''$ in greatest thickness. When brought to me it had been broken into two, the fresh surfaces showing a perfectly compact structure of pale pinkish-buff colour marbled with vein-like markings, a few specks of quartz being also visible. It was evident that the markings very closely resemble a fluidal structure, and the rock a Rhyolite. Hoping to place this beyond doubt, I had a thin section cut, and then found that the structure was very similar to that of some of the "devitrified Pitchstones" described by Mr. S. Allport. With transmitted light it seems to be a tolerably clear glass, in which is a quantity of opaque dust,—red with reflected light, and probably Fe_2O_3,—which is often aggregated in wavy, cloud-like irregular bands. There are a few larger grains of the same. With crossed Nicols the glass breaks up into the usual mosaic of light and dark granules of a rather irregular form characteristic of a devitrified glass. It has some resemblance to fragments in certain of the Charnwood agglomerates, but a still closer to slides cut from devitrified pitchstones from the Wrekin, to which (allowing for the paler colour) it has to the eye a considerable likeness. It must, however, be admitted that macroscopically, and to some extent microscopically, the rock resembles a specimen, given to me by Dr. Hicks, from Treffgarn (Pembrokeshire), which Mr. T. Davies considers of sedimentary origin. Still, though the above-described is a little anomalous, I think it more likely to be a true igneous rock. I have lately found another pebble of the same kind."

At Upware the larger pebbles are much rarer than at Potton, only a very scanty sprinkling of 2-inch pebbles being seen upon the heaps of rejected rubbish. The phosphatic masses themselves are

[1] Jurassic chert occurs in England in the Purbeck and Portland beds of Wiltshire and the Isle of Portland. Mr. E. B. Tawney tells me of beds of chert in the Lower Lias of Glamorganshire; and in the North of England Mr. J. F. Walker, of Sidney College, kindly refers me to such deposits in the Coralline Oolite near Malton.

also markedly smaller at Upware, so that there is much reason to believe we are here further from the source of the pebbles than at Potton.

Amongst the non-phosphatic fragments we find the same tile-like fragments of ironstone, pebbles of dark grit, and other relics of an older Neocomian deposit as at Potton; of the Jurassic rocks, fragments from the underlying Coral Rag are most conspicuous, especially in the basement bed. Of the pebbles of more ancient rocks we also find the same prevailing types as at Potton; vein-quartz and quartzite are especially abundant, also chert of many varieties. The indurated argillites are also common, and jasper is occasionally found.

Some fragments of a pale micaceous laminated grit occur, which may well have had the same origin (Upper Cambrian or base of Silurian, Sedgwick) as the specimens *i* and *k* from Potton.

Other Localities.—Following the outcrop of the Upware and Potton ironsand series southwards to Brickhill and Farringdon, the same small pebbles of quartzite, chert, and Lydian stone occur, vein-quartz being most abundant at the latter place. Again, at Godalming and Folkestone quartz pebbles are abundant, and the "dark-coloured shiny stones" of Mr. Meyer[1] appear to be our cherts and Lydian stones. In the Lower Greensand of Redcliffe and Shanklin, Isle of Wight, there occur irony grit, compact quartzite, reddish quartzite and jasper.

Thus we find that a certain set of pebbles characterizes the Upper Neocomian beds of the East and South of England. A more remarkable fact is, that in the Neocomian rocks of North Germany we again find the same set of pebbles, including the characteristic subangular polished chert fragments and the phosphatic nodules. The Neocomian rocks of Berklingen and Shœppenstadt, near Brunswick, contain beds of calcareous conglomerate with phosphatic nodules, irony fragments, and subangular chert, scarcely distinguishable in general appearance from the Upware conglomerate.

The Portlandian conglomerate of the country around Swindon must also be noticed here, on account of its included pebbles. This bed, which is well seen on Bourton Hill, is a calcareous conglomerate with scattered pebbles very similar in appearance to the Upware conglomerate. The pebbles are almost exclusively chert, mostly dark coloured, some jaspery. I have not been successful in the search for organisms in them under the microscope. Pebbles of syenite, greenstone, chert (?) and other rocks are described from the conglomerate beneath the Gault, discovered in the Kentish Town Boring.

The original homes of the pebbles.—In the unpublished work before referred to, I discuss the origin of the phosphatic and other Neocomian pebbles, and come to the conclusion that while some of them (*Ammonites deshayesii*, *Endogenites*, as also many of the indigenous species) seem to be of southern origin, others, namely, the dark grits with fossils, point to northern deposits, such as the Lower Neocomian sands of Tealby, as their original home.

[1] Geol. Assoc. Report, Dec. 4, 1868.

A glance at the map will show that the Upware and Potton beds rest upon members of the Upper and Middle Oolites, and most of the Jurassic pebbles, phosphatic or otherwise, are doubtless of local origin. But some of the Portlandian masses with *Cyrena* (?) *rugosa*, etc., are decidedly southern, identical with the Swindon Portlandians; and a particular set of shells, including *Pholadomya tumida*, Ag., and *Myoconcha portlandica*, Blake, are remarkable as occurring also as *derived* fossils in a band of the Portlandian group at Swindon.[1]

Bunter beds, capable of furnishing pebbles such as many of our quartzites, and likely to have been exposed at that time, lie roughly between two lines drawn N. and N.W. from Potton. The hard sandstone pebbles *g*, are likely to be from the Coal-measures, and many of the remainder are probably of Silurian, Cambrian, and pre-Cambrian ages.

The set of fossils in the pale slaty pebble *k*, points to the Bala or the May Hill group; the general appearance of the rock being nearest to the Shropshire Caradocs; but it is more perfectly cleaved than the Onny river-beds. This occurrence of Lower Palæozoic fossils is also of value as supporting evidence of the nature of the indurated argillites or Lydian stones *h*, many of which closely resemble the more earthy varieties of dark chert. Many of the quartzites *c*, and the rhyolite *n*, are probably of similar primæval date. We have already seen that the chert was derived from both the Carboniferous and Jurassic periods.

In reasoning from these materials concerning the details of their accumulation, it is of the first importance to determine whether the pebbles were obtained *directly* from the parent rock in Neocomian times, or only indirectly from earlier pebble beds; and, again, we must consider wether they were carried to their present positions solely by marine currents, or had been brought down from the land by rivers. Some of the quartzites are like those of the New Red Sandstone pebble beds, and were probably thus derived, but the majority of the rocks are not similar to those of common occurrence in the older conglomerates.[2] In connexion with the abundant angular chert fragments, a specially noteworthy fact is the absence of any trace of the mother-limestone itself; and yet the Mountain Limestone is a very durable rock under wave action, and there is nothing in the Upware deposit to hinder the preservation of any included calcareous fragments.

Perhaps the best evidence of the *direct* origin of some of the older pebbles is the fragment of fossiliferous Lower Palæozoic rock, whose very angular contour excludes any theory of repeated transport.

The general physical features of the Neocomian period are pretty well known, and an outline of some of these facts will here be of service to us in discovering the source of the more ancient pebbles.

[1] See Blake on the Portlandian rocks of England, read before the Geological Society, January, 1880.

[2] It is indeed remarkable that in the New Red Sandstones we know of no such accumulations of chert pebbles, derived from the Mountain Limestone, to correspond with the abundant flint pebble and gravel beds of Tertiary and modern times. There must surely be some such deposits somewhere hidden in the New Red.

The present westerly line of shallow water, sand and pebble beds, marks closely enough the ancient west coast-line. The Northern Neocomian Sea (Anglo-Germanic), extending E. and W. from Yorkshire to Brunswick was freely open to the north, but gradually shallowed to the south over Norfolk and Cambridge, till it beat upon the shores of the ancient east and west ridge of Palæozoic rocks (the Harwich axis), now hidden under the Cretaceous and Tertiary deposits. By gradual depression and denudation this ridge came to form only an imperfect barrier, perhaps a scattered chain of islands marking off the Northern Sea from the Southern (or Anglo-Parisian) basin, the two seas surging together through newly-made channels.[1] It is to this old ridge that I look for the origin of most of the more ancient pebbles found in our Neocomian deposits; as well from the inadequateness of other theories as from the likelihood of such a source of supply in itself.

The other rock surfaces of the period can be restored with some certainty. The rocks of the country to the west of the Upper Neocomian shore-line were of much the same general character as at present. The same series of Jurassic rocks overspread the country to the north-west and south-west, only ranging further west than at present; and the New Red Sandstone was also more widespread than now. The Mountain Limestone of Derbyshire and the ancient rocks of Charnwood were also to some extent exposed. Now, regarding this country as a source of pebble supply, we find a large area of Jurassic and New Red rocks, and single, isolated, and distant patches of primary rocks. But looking at the pebbles in the Upware and Potton sands, we find, after eliminating the Upper Jurassic fragments of local cliff origin, that the older Jurassic and New Red pebbles are but scantily represented, while Mountain Limestone chert, and other older Palæozoic rocks are abundant. The Derbyshire Mountain Limestone is, therefore, I believe, utterly inadequate as a source of supply for the quantity of chert in our Neocomian deposits, and still less was the Charnwood inlier capable of supplying the quantity of Lower Palæozoic pebbles.

The pebble bed discovered in the Kentish Town deep-boring tends further to show that many of the more ancient rock fragments were not derived from any existing exposure. There, nearly thirteen feet below the base of the Gault, occurs a "hard red conglomerate, with pebbles of syenite, greenstone, trap, quartz, hornstone, red claystone porphyry, and fossiliferous schist from the size of a marble to that of a cannon ball." Some of the lower beds also contained pebbles, but these are small. White quartz is named as the material of these in one case, and small angular fragments of chert (?) in another.[2] And these beds probably rest upon the old Palæozoic ridge.

But little of the constitution of this ancient ridge and barrier has yet been directly revealed. Its date being Post-Carboniferous, we should naturally expect large exposures of Mountain Limestone

[1] In earlier Cretaceous times (Lower Neocomian) the two seas could have communicated only by their common union with the Atlantic in the west.

[2] Mem. Geol. Survey, vol. iv. p. 498.

along its boundaries; and I regard the chert pebbles above described as relics of such rocks, they having been separated out from the mother-limestone by the delicate sifting power of running water. The shaly rocks of the Harwich deep boring probably belong likewise to the Carboniferous period, and those of Meux's Brewery are true Devonian. The recent deep boring at Turnford also discovered Devonian rocks, and that at Ware Silurian (Wenlock Limestone), and the relations of these beds are such that, as Mr. Etheridge writes, "Should the dip of these Hertfordshire Silurians prove to lie to the south, we may anticipate the more ancient series further north towards Cambridge."[1] The dip of the Hertfordshire Silurians *is* proved to lie to the south, and thus we find the details of the ancient barrier, so far as yet known, strongly supporting our independent conclusions that the more ancient Palæozoic pebbles were derived from this source. And at this period the old dividing ridge must have been suffering active marine denudation from waves, and the wash of strong currents between the two N. and S. seas; the advancing waters steadily widening the gaps in the old barrier as it gradually disappeared beneath the sea surface. The conditions were therefore peculiarly favourable to the formation of pebble beds, and then it was that our Upware and Potton pebbles were formed, the Jurassic ones mainly from the western shores in Cambridgeshire and Bedfordshire, and the Carboniferous and older Palæozoic from the destruction of the ancient barrier.[2] The Rhyolite pebbles may have been obtained, like many of the quartzites, indirectly through the New Red Sandstone.

Lastly, inquiring what we can learn from these fragments as relics of beds since destroyed by denudation, we find the Jurassic chert pointing to the former existence of Jurassic limestone near to this area, and the abundance of Mountain Limestone chert proves a great denudation of the Carboniferous formation. But little evidence appears bearing upon the question whether Coal-bearing beds now form part of the Palæozoic ridge; but the more ancient pebbles testify to the existence of the older Silurian and Cambrian rocks beneath the Cretaceous series near Cambridge, as independently predicted by Mr. Etheridge.

The almost exclusive presence of chert in the Portlandian pebble beds of Berkshire suggests that only the Carboniferous rocks were exposed to denudation in Upper Jurassic times, the Mountain Limestone wrapper being not yet eaten through so as to expose the more ancient core-rocks of the axis.

VI.—Note on the Well lately sunk at Wokingham, Berks.

By Prof. T. Rupert Jones, F.R.S., F.G.S.

HAVING been favoured by Mr. T. M. Quill, who has of late successfully completed an artesian well at Wokingham, with opportunities of examining the specimens brought up from the well, and with his own notes on the progress and results of the boring,

[1] Popular Science Review, 1879, vol. iii. p. 293.

[2] Mr. J. J. Harris Teall suggested, in 1875, that the Lydian stone came from Palæozoic rocks to the east.—Sedgwick Prize Essay, 1875, p. 38.

I have drawn up a tabular statement of the strata pierced on that occasion. The well was begun in May, 1879, in the London Clay, on the low ground at the foot of the hill of Bagshot Sand on which Wokingham stands, near the junction of the S.W. and S.E. Railways. A 6-foot shaft was sunk for 264 feet, penetrating the London Clay; a 24-inch pipe, through 6½ feet of sand and clay of the "Basement Bed," then reached a water-bearing sand of the same series; and a pipe (16-inch) and bore-hole were continued for 138 feet, down to 408 feet, at a level of 64 feet in the Chalk, where an abundant supply of water was obtained. The 16-inch pipe was sunk to 355 feet, having sunk several feet in the Chalk by its own weight (18 tons) on the cutting edge of its "shoe." From 355 feet down to 408 feet, a 15-inch bore-hole was made in the solid Chalk and flints, without any pipe to line it. The pipe traversed the lower part (3½ feet) of the "Basement Bed of the London Clay," 54½ feet of mottled clays and sand of the "Woolwich and Reading Series" (with water in sand at 295 feet), and 16 feet of the sands and "Bottom Bed" of that formation, before it entered the Chalk. No Oyster shells were observed in the "Bottom Bed." The grey colour attributed to the upper portion of the Chalk (at 344′ to 352′) may have been caused by the admixture of greenish sand occupying perforations in the Chalk, as in other parts of Berkshire.

The following are the details:—

At top 1 foot of surface soil. Thickness of Beds in feet.	Depth in feet.	Strata passed through in sinking the well at Wokingham, Berks.
263 feet of London Clay. (263 feet of London Clay.)	1	London Clay, fawn-coloured (weathered).
	5	Rusty-brown (weathered); with small Bivalves (*Cardium*).
	12	Blue and compact (drying on exposure to dark-grey); Septarium, with large Bivalve (*Cyprina*).
	14	Septarium, with small *Cardium*; *Pholadomya virgulosa* (pearly), large and small, in the clay.
	18	Large *Nautilus* in septarium.
	45	*Cyprina planata* (large), several.
	52	Seam of rounded flint shingle of large and small pebbles, grey-mottled outside, whitish within.
	62	*Pholadomya virgulosa.*
	70	*Panopæa intermedia.* (Loamy from 70′ to 82′, with water.)
	70½	Septarium with pyrites.
	73	Thin seam of black (flint?) sand.
	73½	Septarium.
	81	Septaria: 1 foot.
	90	*Pholadomya virgulosa* (pearly).
	95	Septarium with pyrites; and nodule of pyrites, irregular in shape.
	120	*Teredo*, piece of thick tube.
	125 to 137	Loamy.
	147	Septarium.
	155	*Pinna*, crushed fragment.
	162	Septarium.
	184	*Dentalium*, *Acteon* (pyritous), and *Natica* in the clay; and a septarium.
	189	Septarium.

	Thickness of Beds in feet.	Depth in feet.	Strata passed through in sinking the well at Wokingham, Berks.
		209	Flint pebbles, large, $3\frac{1}{2}''$ long, and $6''$ long by $3\frac{1}{4}''$ thick, grey-mottled outside, white and yellowish within, with yellow and faint umber concentric colours in middle, with grey spots, somewhat like Choanite structure.
		210	Cement-stone in flat nodules, with irregular perforations,[1] roughly striated on their inside (Fucoidal).
		225	*Astarte* ($\frac{1}{2}''$ long).
		228	Septarium.
		235	*Astarte* ($\frac{1}{2}''$ long)
		259	Cement-stones, and beneath them a seam of black sand, with water.
10 feet of sandy and pebbly "Basement Bed" of the London Clay.	1′	264	Dark-grey loam sand and shale; with Bivalves (*Cytherea tenuissima*, about $1\frac{1}{4}''$). Water here, at 120 gallons an hour.
	1′	265	Fine quartzose sand, with green grains and a little mica: *Ditrupa.*
	2′	266	Cement-stones.
	1′	268	Dark sand with shells.
	$1\frac{1}{2}$	269	Clay, and flat nodule of pyrites, containing fragment of large Bivalves, and rough perforations like those in the Cement-stone at 210 feet.
	3′	$270\frac{1}{2}$	Sand and sandstone (as at 265′), with *Ditrupa;* small black flint pebbles, and a small angular piece of rock. Thin seams of clay in the sand. Water rose 126 feet in the shaft, and would probably have risen 150′ had it not been pumped.
	$\frac{1}{2}'$	$273\frac{1}{2}$	Glauconitic clay.
54 feet of Clays, mottled and various, with some sand.—"Woolwich and Reading Beds."	2′	274	Mottled clay.
	4′	276	Reddish clay.
	5′	280	Brownish clay.
	4′	285	Mottled clay.
	1′	289	Sandy clay.
	1′	290	Friable clay and sandstone.
	2′	291	Brown loamy clay.
	2′	293	Hard mottled clay.
	2′	295	Grey sand and water. Water suddenly burst up the $16''$ pipe, and rose to within 42 feet of the surface.
	2′	297	Loamy clay.
	2′	299	Seam of sand with clay.
	2′	301	Mottled green clay.
	3′	303	Sandy clay.
	$6\frac{1}{2}'$	306	Mottled brown and red clay.
	$1\frac{1}{2}'$	$312\frac{1}{2}$	Sandy clay.
	2′	314	Greenish loamy clay.
	1′	316	Mottled clay.
	4′	317	Brown clay.
	$\frac{1}{2}'$	321	Grey sand.
	$3\frac{1}{2}'$	$321\frac{1}{2}$	Mottled clay, with thin seams of greenish sand.
	3′	325	Mottled clay with sand.

[1] These perforations are similar in character to those in the surface of the Chalk underlying the "Bottom Bed" of the Woolwich-and-Reading series at Reading and Newbury. These oblique and irregular holes, crossing one another, have been referred, with great probability, by Mr. Hudleston, F.G.S., to "roots of marine plants" growing on the sea-bottom ("Proceedings Geol. Assoc." vol. iv. p. 521). Some of the perforations in the Chalk at Newbury (I may remark) are more horizontal than the others, are situated below the oblique holes, and are filled with a granular (perhaps fœcoidal) chalky material.

	Thickness of Beds in feet.	Depth in feet.	Strata passed through in sinking the well at Wokingham, Berks.
16 feet of Sand and "Bottom Bed."	15′	328	Grey sand (with a thin seam of clay at 335 feet).
	1′	343	Green sand, with green-coated pebbles (few) and sub-angular flints.
64 feet of Chalk.	8′	344	Soft grey[1] chalk.
	11′	352	Band of flints and clear white chalk.
	3′	363	White chalk with scattered flint nodules.
	5′	366	White chalk.
	31′	371	Band of flint, and others at intervals down to 402′.
	6′	402	Band of flint (over 12″), with soft chalk under it, which yielded water at 15,000 gallons an hour[2] (May 28, 1880).
		408	Hard rock (flint), not pierced.

We must bear in mind, that in boring it is not always easy to be certain of the exact character of the beds to a few inches, as the material gets mixed up to some extent in the boring tools.

Some published sections of the Tertiary strata in this part of England, which may be useful in comparison, are to be found in the Quart. Journ. Geol. Soc. vol. x. p. 89; vol. xxxi. p. 451; Memoirs Geol. Survey, vol. iv. p. 423, etc.

VII.—Notes on the Vertebrata of the Pre-Glacial Forest Bed Series of the East of England.

By E. T. Newton, F.G.S.,
Assistant Naturalist, Museum of Practical Geology, Jermyn Street, S.W.

PART II.—CARNIVORA.

On the Occurrence of the Glutton, *Gulo luscus*, Linn., in the "Forest Bed" of Mundesley, Norfolk.[3]

In some notes communicated to the Geological Magazine last April (p. 152), attention was called to the fact that remains of the Glutton had been recently obtained from the "Forest Bed." So much interest is attached to the discovery of an animal, which at the present day is restricted to the cold northern regions, along with Elephant and other remains, which seem to indicate a warm climate, that it has been thought desirable to give some account of the discovery. I am indebted to Mr. R. Fitch, of Norwich, to whom the specimen belongs, for his courtesy in submitting it to me for examination. It is a portion of a lower jaw with teeth, of a Glutton, *Gulo luscus*, Linn., a genus which, although known to occur in the fossil state, has hitherto only been obtained from Cave deposits.

The occurrence of the Glutton in Britain was first intimated by MM. Boyd Dawkins and Sanford in the year 1866 (Pal. Soc.), but it was not until 1871 (Q.J.G.S. vol. xxvii. p. 406) that the former gentleman described the lower jaw of this species, which had been obtained by MM. Hughes and Heaton from the cave at Plas Heaton.

[1] This greyness may have been due to the intermixture of sand lying in perforations in the top of the Chalk.

[2] At 70 feet below the surface.

[3] Read before the Geological Society of London, May 12, 1880.

Prof. Busk subsequently recognized the remains of the Glutton among the bones found by the Rev. J. M. Mello in the Creswell Crag Caves (Q.J.G.S. vol. xxxi. 1875, p. 687).

The presence of the remains of this animal in the German Caves had been made known by Dr. Goldfuss in 1818 (Nova Acta, tom. ix. p. 311). Dr. Schmerling recorded its presence in Belgium in 1833 (Oss. Foss. Liége, p. 167), and M. Gervais noticed its occurrence in France in the Cave of Fouvent (Haute Saône) in 1867 (Zool. et Paléont. General, p. 252). The specimen figured by Dr. Kaup as *Gulo diaphorus* (Oss. Foss. 1832) most certainly belongs to another genus.

All the fossil remains of the Glutton hitherto known, both in Britain and on the Continent, have been obtained, as above mentioned, from Cave deposits, and are consequently of somewhat uncertain age; the finding of the specimen which forms the subject of this communication is therefore of especial interest, as it shows that the animal lived in Britain during the time when some of the beds forming the "Forest Bed Series" were being deposited, and consequently it carries back the advent of the Glutton in Britain into what are usually regarded as pre-glacial times.

This "Forest Bed" specimen, as already intimated, is the property of Mr. R. Fitch, and is preserved in his magnificent collection at Norwich. It consists of about two inches of the left ramus of the lower jaw, with the first true molar, or sectorial tooth, in place, together with the hinder half of the fourth pre-molar. Part of the alveolus for the second true molar is likewise preserved, and this is fortunate, for the Plas Heaton specimen is defective in this latter particular, the jaw being broken away behind the first true molar. The entire surface of the "Forest Bed" specimen presents that peculiar grooved and channelled appearance not uncommon among fossils from these beds. The Plas Heaton specimen is shown by Prof. Boyd Dawkins to be larger than the recent one in the British Museum, with which he compared it; on the other hand, the lower jaw now under consideration is much smaller, and corresponds more nearly in size with a Glutton's jaw preserved in the Museum of the Royal College of Surgeons, and, with the exception of this slight difference of size, the two are so precisely alike that the description of the fossil given below would answer equally well, in every particular, for the recent specimen. It is through the kindness of Prof. Flower that I am enabled to give figures of this recent jaw for comparison with the fossil one (Pl. XV. Figs. 4–6).

The outer surface, below and behind the first true molar, becomes concave as the jaw curves outwards to the prominent angular portion, and the depression for the masseter muscle is deep. The inner surface is convex, especially towards the alveolar border. The teeth are implanted towards the outer side, a peculiarity of the Glutton's jaw pointed out by Professor Boyd Dawkins, and consequently the crowns overhang the outer surface. The large sectorial tooth, *m.* 1, has its two cusps so nearly equal in size that the trifling superiority of the posterior one is scarcely perceptible. These cusps are separated on the outer side by a short slit which is enlarged below. The outer surface of the crown is uniformly convex from before backwards in the region of these cusps, and becomes concave at their junction with the heel. From above, the cusps are seen to be very thick and solid, and to extend quite to the inner side of the tooth. There are no accessory cusps or tubercles, unless the very slight inequality of the flattened upper surface of the heel should be regarded as such. The hinder surface of the posterior cusp is flattened as if by attrition with the upper grinders. The portion of a small alveolus, behind the sectorial tooth, shows that this jaw had a small second true molar. The hinder portion of the fourth pre-molar has a sharp prominent keel, descending from the point of the cusp to the hinder border of the crown, and somewhat towards the outer side. On the inner side of this there is a flattened surface terminated below by the hinder edge of the tooth, which is raised into a ridge so as to form a kind of guard. There is no indication of a secondary cusp or tubercle upon this keel. Although the surfaces of the teeth have been channelled and grooved during the process of fossilization, yet, with a pocket lens, the original roughened surface is still visible on the intermediate portions.

The following measurements of the Plas Heaton specimen and of the recent one in the British Museum are copied from the table given by Prof. Boyd Dawkins (Q.J.G.S. vol. xxvii.); the corresponding measurements of the "Forest Bed" lower jaw being added in the right-hand column. The lower jaw of the Glutton in the Museum of the Royal College of Surgeons is intermediate in size between this British Museum specimen and that from the "Forest Bed." The measurements are given in fractions of an inch.

	Plas Heaton specimen.	Recent Glutton in Brit. Mus.	"Forest Bed" specimen.
Depth or ramus below m, 1 ...	0·96	0·85	0·72
Length of m. 1.	0·95	0·82	0·75
Width ,, ...	0·42	0·34	0·30
Height ,, ...	0·42	0·36	0·33

Judging from the amount of variation, in regard to size, observable among the recent individuals of *Gulo luscus*, and the identity of form between these and the "Forest Bed" specimen, in as far as this is preserved, one cannot do otherwise than refer the latter to the same species.

With regard to the particular horizon of the "Forest Bed Series" from which this Glutton was obtained, we are happily in possession of exact information. Mr. Fitch purchased the specimen from the finder, Mr. W. Dix, of Mundesley: and my colleague, Mr. Clement Reid, has taken the trouble to visit the spot with Mr. Dix, and in a letter he assures me that "Mr. Fitch's specimen was found half a mile S.E. of Mundesley in the 'Forest Bed' at the same horizon at which so many large bones are found." There is, therefore, no room for doubting that this *Gulo luscus* was obtained from a bed low down in the "Pre-Glacial Forest Bed Series" near Mundesley.

EXPLANATION OF PLATE. XV.[1]

GULO LUSCUS, Linn.

All the figures are natural size, and their correctness is guaranteed by their being drawn from nature by my friend and colleague Mr. G. Sharman.

FIG. 1. Portion of a left ramus of mandible, from the "Forest Bed" of Mundesley, outer side.
,, 2. Ditto, inner side.
,, 3. Ditto, viewed from above.
,, 4. Left ramus of a recent specimen in the Museum of the Royal College of Surgeons, outer side.
,, 5. Inner view of portion of same.
,, 6. View of same from above.

REVIEWS.

GEOLOGICAL MAP OF ENGLAND AND WALES. By HENRY W. BRISTOW, F.R.S., F.G.S., Director of the Geological Survey of England and Wales. (Letts, Son, & Co.)

A GEOLOGICAL Map at the cost of about $2\frac{1}{2}d.$ naturally creates such a feeling of scepticism that we would recommend our readers to purchase Part 4 of Letts's Popular Atlas (price 7*d.*), which includes: 1. A Geological Map of England and Wales; 2. A General Map of Africa; and 3. A General Map of the Austrian and German Empires. The size of the maps is about 1 ft. 1 in. by 1 ft. 4 in., and all are printed in colours. Twenty-two geological divisions are shown in Mr. Bristow's map, and although the printing is not such as would satisfy the mind of the critic, yet when we consider the price, we can but marvel at the production. The beds least clearly defined are those between the Coal-measures and the Oolites. The Permian and Trias are often so difficult to distinguish in the field, that a blending of them on the map does not matter; but the Lias in the Midland Counties, as shown on the map, is not sufficiently distinct at a glance. The map, however, improves upon acquaintance, and it really is an old friend in a new guise, being founded on the map published under the Superintendence of the Society for the Diffusion of Useful Knowledge. The original edition was, we believe, issued in 1834—being then based chiefly on the works of William Smith, of Conybeare and W. Phillips, and of John Phillips. A newer edition by Sir Roderick Murchison was prepared in 1843 by S. P. Woodward, and this included the work of Sedgwick, Murchison, and De la Beche in Wales and the West of England. From time to time improved editions of Murchison's map were published, the revisions being chiefly those due to the progress of the Geological Survey, to which Mr. Bristow himself has in no small degree contributed. The present edition includes important revisions of the map in parts of Devonshire and in the northern counties of England, and of the numerous marginal notes which furnish many local details of geological interest. All the leading railways are very prominently shown.

[1] The Plate will appear in the October Number.

CORRESPONDENCE.

ON THE FORMATION OF THE DIAMOND IN THE TERTIARY DRIFTS OF NEW SOUTH WALES,[1] ETC.

After referring to the recent artificial production of the diamond by Mr. Hannay, the writer adds:

"When examining the New England and Mudgee Districts in New South Wales, I came to the conclusion, as did Mr. Norman Taylor also, that the diamonds (of which hundreds were found in the gold and tin drifts) had been chemically formed in the Miocene and Pliocene Cements, which are very ferruginous and sometimes siliceous, the waterworn pebbles being found coated with a film of silica. The recent alluvium only where derived from the Tertiary drifts is diamond-bearing; and the Tertiary drifts themselves contain diamonds; but the older rocks, Silurian, Devonian, or Carboniferous, do not contain them, or rather, the recent alluvium derived from them does not, although the Tertiary drifts themselves have also been derived from the same Palæozoic rocks; therefore, we can only conclude that the diamonds have been formed in the drifts.

"These drifts are nearly always capped with basalt. I believe from the nature of the rocks that water containing some carbonate in solution, and also silica, was present, a chemical reaction taking place and setting free the carbon in a crystallized form. In the same way, I believe, the minute scales or crystals of graphite have been formed in our Hawkesbury Sandstone (Triassic). This sandstone consists of (originally) rounded grains of quartz sand, coated now with silica in a crystallized state, and with the scales of graphite scattered through it. The sandstone, when broken, has quite a glittering appearance, from the silica coating the rounded grains of sand with the graphite occurring at intervals through the mass. I mentioned this to Prof. A. Liversidge, but he thinks the scales of graphite were deposited with the sand; I think not, however, for the sandstone, so false-bedded, etc., bears evidence of deposition by strong and variable currents of water, which would have destroyed the small graphite grains by attrition. On this account I think the graphite must have been chemically formed during the slow transmutation which the sandstone has undergone. We shall be much interested to hear of Mr. Hannay's process for making the diamond."

C. S. Wilkinson, F.G.S.,
Government Geologist for N. S. Wales.

ECCENTRICITY AND GLACIAL EPOCHS.

Sir,—Mr. Greenwood's demonstration in the July Number (p. 332) looks clear, but is, I think, not quite sound. The error is rather subtle, and not easily made out. I believe it to consist in attributing to the sun's heat only the actions of melting snow and raising temperatures, which tacitly neglects its primary action of supplying the place of that heat which the earth and its atmosphere are

[1] In a letter to R. Etheridge, Jun., dated "Sydney, 9th April, 1880."

perpetually radiating away. When this is brought into the reckoning, there is no such decrease in available energy as Mr. Greenwood's argument supposes. The reason for expecting that the winter snowfall will be increased with increased eccentricity is that the heat-receipt during winter will be then diminished. Some vapour which the sun's heat might have maintained as vapour during the winter, will then radiate off its heat without compensation; will be chilled and fall as snow. But the summer's receipt of heat is increased, increased to the exact extent of the winter decrease, and so to the extent required for the dissipation of the supposed additional snow. The heat thus spent in dissipating Mr. Greenwood's extra foot of snow would before the increase of eccentricity have been spent in preventing that snow from being formed. There is no increase of work to be done.

Mr. Greenwood's argument would become correct if the snow were supposed to be generated in some different region, and thence brought to the region considered. Obviously a room will be chilled if a block of ice be introduced.

I find it difficult to reconcile the language of Mr. Greenwood's second paragraph with the article which it criticizes. He says that I argue from "increased radiation being greater in proportion to the increase of temperature." He probably means, "greater *than* in proportion." He says that I ignore the fact that if radiation is increased in greater proportion by a rise in temperature, it is decreased in like proportion by a fall. This fact is only roughly true, just as when a conical vessel contains water, it is true that whether the water level be raised or lowered an inch, the quantities to be poured in or poured out are nearly the same. But only roughly, not quite. The equality is not perfect. This is pointed out at some length in the article considered, and the argument questioned by Mr. Greenwood was built on this absence of equality. The words "ignore" and "fact" seem incorrectly applied.

The question is at present scarcely worth discussion. Mathematical calculation of the effect is environed with apparently insuperable difficulties. But the rough attempts at calculation which I have made lead me to suspect that its amount is insignificant, and not even inadequate to alter mean temperature by a degree.

St. John's College, Cambridge, *Aug.* 10. E. Hill.

SCLEROTIC BONES OF COAL-MEASURE REPTILES.

Sir,—Would you kindly permit me to inform your readers that I have obtained from the Northumberland Coal-measures a perfect ossicular sclerotic ring of a Carboniferous reptile? It consists of eight ossicles of a quadrate form which slightly overlap each other and produce a perfect ring, the central opening of which is $\frac{5}{16}$ths of an inch in diameter; and the extreme diameter of the ring of ossicles is $\frac{5}{8}$ths of an inch.

I have also obtained a series of six sclerotic ossicles lying in regular order. The ring, if complete, indicates the existence of about 24 ossicles, and the central opening about $\frac{5}{8}$ths of an inch in diameter.

I have neither seen nor heard of any other sclerotic plates having been obtained from British Carboniferous strata, and shall be glad to know if any collector of British Coal-measure fossils has obtained specimens from any British colliery or coal strata.

26, Archbold Terrace, Newcastle-on-Tyne, *July* 17, 1880. T. P. Barkas, F.G.S.

FOSSILS ON TRANSVERSE CLEAVAGE PLANES.

Sir,—Will you kindly accord me a little of your space to give publicity to certain observations which I have made upon the above subject?

The possibility of fossils occurring upon cleavage planes, when those planes do not happen to be coincident with the bedding, first occurred to me as a question in connexion with investigations made by me somewhat more than a year ago in the Culm-measure Limestones of Westleigh, in Devonshire. A (?) fossil seemed to occur on a (?) cleavage plane. This I showed to several competent judges, to whose opinions I should usually, and with good reason, readily yield. But in this instance opinions were conflicting. First, by some I was told that it was a fossil, and that *therefore* the plane on which it occurred was a bedding plane, not cleavage. Next, by others I was told that the plane was certainly a cleavage plane, and (*ergo*) that the supposed fossil was no fossil.

This set me considering whether there could be no *via media* in the matter. And I found, when I began to make inquiries, that better geologists than myself had observed similar phenomena, and confessed themselves to be perplexed by them.

I do not lay any great stress upon the Westleigh specimen. I confess myself to be very doubtful now about its organic origin, though at one time I held a different view. It, however, led me to make inquiries elsewhere, and through the kindness of Mr. H. B. Woodward, Mr. Kinahan, and Mr. W. Hughes of the Victoria Slate Quarries, Carrick-on-Suir, Ireland, I was furnished with specimens which were perfectly convincing as to the fact, account for it how we may.

The first specimens sent to me by Mr. Hughes from these Lower Silurian rocks showed Graptolites and Fucoids upon what he affirmed to be cleavage planes, but, not feeling quite satisfied about the matter, I wrote to him again, asking for details of the structure of the rocks, and pointing out, by means of drawings, that the cleavage which in one place was inclined at a high angle to the bedding might elsewhere, through the folding of the beds, become coincident with the bedding.

To this he replied by sending me a specimen in which both bedding and cleavage were shown. The former was shown by colour streaks, and upon the latter, inclined to the bedding about 80°, was a Fucoid impression. He says: "*In no part* (*of the quarry*) *are the bedding and the cleavage coincident.* We find the fossils occurring on the cleavage in different parts of the quarries, whatever position the latter may hold with regard to the bedding." He added also that the fossils are "not always exactly coincident with the cleavage," and one of his specimens illustrated this.

I repeat, therefore, that there can be no question whatever as to the fact. I then set myself to work to account for it.

The first question which I proposed to myself was this, "How can fossils be deposited otherwise than on a plane of bedding?" And it appears to me to be no very difficult one to answer. Various exceptional circumstances might account for them in isolated cases; but for a common cause affecting a wide area of rock, we need only suppose tranquil conditions of deposit. Where there is absolutely no current and a soft oozy bed, shells, etc., would fall with the major axis in a perpendicular position, and in such a position they might probably remain. For some reason or other *Turrilites* is found "invariably at right angles to the stratification,"[1] in the Chalk-marl of the South of England. This is due, perhaps, in the first instance, to the fact that it is a Cephalopod; but it is evident that, if a current existed at the sea-bottom, the fossil would assume a horizontal position immediately after the death of the animal. That it has not done so proves tranquil conditions of deposit.

If we apply the same reasoning to a silty deposit, which has since been altered into slate, it will fully account for such organisms as sea-weeds and Graptolites being found inclined at a high angle to the bedding. Who ever saw a seaweed or Sertularian in a perfectly horizontal position in sea-water, unless perhaps in the tide-race? In still water the comparative buoyancy of their several parts would determine their position. And in such a position the silt would fall around them and entomb them.

The second question which occurred to me, and which is by no means so easy to answer satisfactorily, is this—"How came the fossils to be revealed in so many instances upon a superinduced structure like cleavage?" "How is it that the cleavage plane should happen to be exactly that in which those fossils lie?" I can only suppose that the slate rock at Carrick-on-Suir is in reality densely crowded with such organisms as Graptolites and Fucoids, a small per-centage of which are revealed by the cleavage. If the large majority of the organic remains which have been deposited there are deposited upon the planes of bedding, they are for ever lost to science, for the rock never divides along the bedding planes. The cleavage destroys all traces of the delicate impressions, except those (comparatively few) which happen to have been deposited exactly or very nearly along the lines which the cleavage afterwards followed. But we should expect to find some half revealed by lying imperfectly upon the cleavage plane, and this is exactly what we do find.

In some cases, in irregularly-cracked shales, I have seen cracks diverted, as to their direction, by the presence of a fossil, and perhaps the very selection of the divisional plane, dependent, as it would be, upon the line of least cohesion, may be determined here

[1] Science Gossip, 1879, pp. 204-5.

and there for a few inches by the surface of a fossil; but this, of course, is a distinct thing from regular cleavage affecting a large area of rock. In the latter case a coincidence between cleavage and the lie of a fossil could be but accidental, but that which is accidental may be of not unfrequent occurrence. W. DOWNES.

FOSSILS IN HIGHLY CONTORTED AND CLEAVED SLATES AND FLAGS.

SIR,—For many years the greatly cleaved and contorted Menevian strata of St. David's in South Wales, and of Dolgelly in North Wales, were deemed *wholly unfossiliferous.* At length by piecing together the slates and *looking at the bedding ends* of a number of them placed together in their *natural* position, Messrs. Salter and Hicks were fortunate in discovering a large number of fossils, revealing an entirely new fauna. Many of these fossils, which I remember to have seen, collected by the late Mr. Thos. Belt, F.G.S., and by Mr. John Plant, F.G.S., at Dolgelly; and by Messrs. Salter and Hicks at St. David's; reminded me of nothing so much as a fashion, which was greatly in vogue among elegant triflers and amateur painters, 40 to 50 years ago; of painting portraits and landscapes on the *edges* of books (often Bibles[1] were curiously enough chosen for this purpose). The single leaves themselves of course disclosed no evidence, but by pressing the book very slightly *obliquely* at the edges, a picture was at once revealed to the admiring gaze. The fossils may similarly be said to be, the pieced-together pages of old Cambrian records, cleaved into *blank leaves* by Time, but upon whose frayed and time-worn *edges* may still be deciphered a chapter in the life-history of our earth. F. G. S.

[1] A Reverend Divine, who admired and loved the Queen greatly (as of course we all do), being a man of leisure and of a whimsical taste in art, painted *yearly* a very pleasing landscape, or other subject, upon the front edge of a handsome gilt 4to. Bible bound in Russia or Morocco, and sent it to the Queen on her birthday. These volumes with pictured edges, which extend over very many years of the early life of Her Majesty, are preserved in the Royal Library at Windsor Castle.

MISCELLANEOUS. — M. Delesse has published a useful agronomic map of the Department of the Seine and Marne (Extrait du Bulletin des Sci., December, 1879: Paris, Jules Tremblay, 1880), which comprises the natural region of the *Brie.* In the above notice he has given some details respecting the mode of preparation and the principal results derived therefrom, the persual of which may be useful to those engaged in similar work. The map enables us to compare the revenue derived from the arable lands, the meadows, forests, vineyards, and shows how the fertility of the soil varies throughout the department, and also affords the means of appreciating the relation which exists between the physical and chemical characters of the vegetable soil and the geological structure of the district. It gives also the composition of the vegetable soil, which is further illustrated by two reduced maps appended to this short notice, one showing the lands with and without calcareous matter; the other indicating by different tints and curved lines the proportion of sandy residue corresponding to 20, 40, 60 and 80 per cent. in the soil. J. M.

ERRATUM.—In Mr. W. H. Dalton's letter on "Post-Glacial," in July No., p. 333, line 11 from foot, *for* "Further deposits," *read* "Further, these deposits."

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OCTOBER, 1880.

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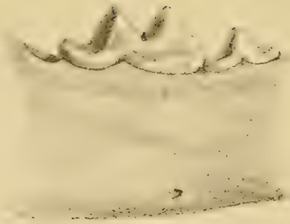

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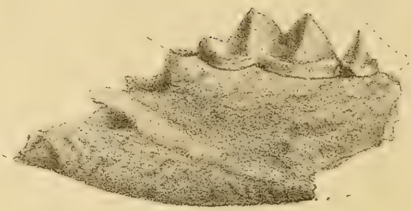

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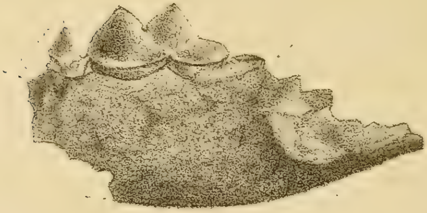

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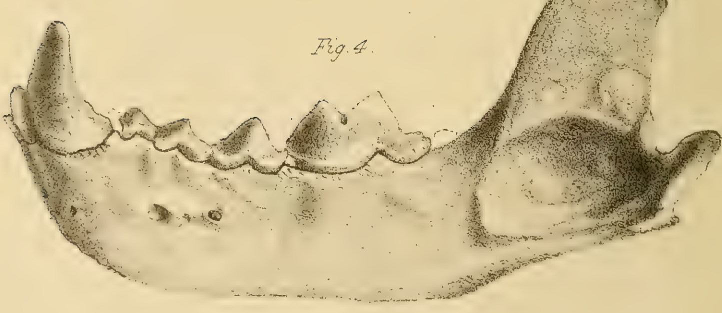

Fig. 4.

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THE

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NEW SERIES. DECADE II. VOL. VII.

No. X.—OCTOBER, 1880.

ORIGINAL ARTICLES.

I.—The Whin Sill of Teesdale, as an Assimilator of the Surrounding Beds.

By C. T. Clough, M.A., F.G.S., of H.M. Geological Survey.

Communicated by permission of the Director-General of the Geological Survey of the United Kingdom.

I WISH in the present paper to draw attention to one aspect of the Whin Sill specially, viz. its aspect as an assimilater, and other interesting points connected with it I shall only mention incidentally, as they may arise during our investigation of this aspect.

Accordingly, I will take it for granted that there can be no doubt that the Whin Sill is not really a "sill"[1] at all, that it is not contemporaneous with the beds among which it lies, but of later date. After noticing the changes in its stratigraphical position, its next feature that is most likely to strike one is, I think, the general absence of signs of accompanying mechanical disturbance. If such an immense and irregular mass has been thrust in among the sedimentary beds, how is it that these beds are not more squeezed and faulted and contorted by it?

The difficulty is one that strikes all the more intelligent miners and geologists of the Dale, and they always bring it forward when you are trying to show them that the Whin Sill is not really a sill. They know that it is not always on quite the same geological horizon, that at one place you can see it resting on a limestone, and at another place on a plate bed, but they get out of this by supposing that fresh beds have come in between the two places. They have the following two propositions presented to them: either the Whin

[1] Perhaps I had better here explain a few North-country words which occur in this paper, and which may not be generally known.

Whin.—Sometimes applied to any very hard bed, as a hard close-grained sandstone, but more especially to hard crystalline rocks, as the Cleveland Basaltic Dyke, and the great mass of stratiform Basalt that occurs in the North of England. This name perhaps comes from the sound the rock makes when flying off under the hammer.

Sill.—Any bed of rock lying more or less parallel with the neighbouring bed, *e.g.* the "Slate Sills" and the "Coal Sills" are particular beds of sandstone in the Yoredale Series. The word is probably connected with the word "sole" (the sole of the foot), and means anything lying flat.

Plate.—Shale.

Post.—The horizontal bands in any bed which are prominently developed on weathering. There is a limestone in the Yoredale Series called the "Single Post" limestone, and it gets its name from the fact that very commonly it does not show any horizontal division lines at all, but remains united in one mass in its whole thickness.

Syke.—A stream, or beck.

Girdle Beds.—Alternations of thin sandstones and sandy shales.

Sill is a sill deposited contemporaneously with the beds among which it lies, or it is a great intrusive mass breaking through and thrusting aside these beds like a wedge. They are on the horns of a dilemma. How can the Whin be a sill when it changes its horizon relatively to the other sills? How can it be an intrusive wedge when there is such a general absence of disturbance in the beds around? William Hutton (Trans. Newcastle Nat. Hist. Soc. vol. ii. part i., "On the Stratiform Basalt Associated with the Carboniferous Formation of the North of England") felt the same difficulty. The unconformity between the Whin Sill and the surrounding beds, which had been noticed by Sedgwick (Camb. Phil. Trans. 1824, "Geology of High Teesdale"), he thinks may be explained by the "putting in" of new sedimentary beds. He says (p. 205, *op. cit.*), "There are many well-known instances of the 'putting in' and thickening of strata in the Coal-field, and Mr. Buddle, in his valuable sections published in the Transactions of the Natural History Society of Newcastle, has shown several: one of the most remarkable of these is mentioned at p. 201, where a bed of sandstone, twenty fathoms thick, is traced thinning out until it becomes a stone band in the Bensham Coal-seam in Wallsend Colliery, and is known finally to disappear."

If there really is such a general absence of accompanying mechanical disturbance, as I have indicated, then it seems to me that we shall be forced to conclude that the Whin consists in part of altered sedimentary beds, that it partly represents beds which were once in the position it now occupies, that it did not make room for itself simply by thrusting aside these beds, but also by incorporating them into itself.

As this conclusion is a very important one, I shall not content myself with taking the fact as proved on the authority of Hutton and the Dalesmen merely, but shall proceed to mention in detail particular sections which show most conspicuously the absence of any disturbance.

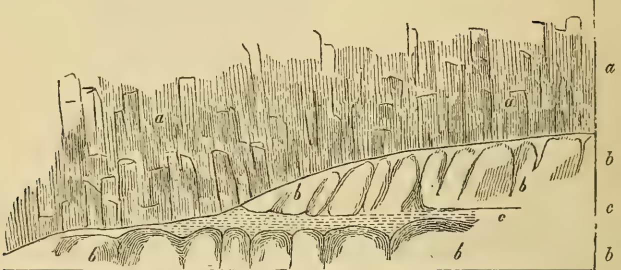

Fig. 1.—Section on the Durham bank of the Tees, 180 yards from the foot of the Maize Beck.

a Basalt. *b b* Posts of saccharoid Limestone. *c* Shale-bed; rather irregular. Length of section, 20 yards.

A few hundred yards below Caldron Snout, and on the Durham side of the Tees, the base of the Whin (or rather of *a* Whin) is seen, with saccharoid limestone below. The section is rudely represented in Fig. 1.[1] The Whin is seen cutting diagonally down through two posts of nearly horizontal limestone: the top post is first of all cut completely through, and then the next is cut partially through. The limestone has not assumed a dip parallel to the inclined Whin base.

On the top of Cronkley Fell, in Yorkshire, the beds above the Whin are lying almost horizontally, and are as follows, beginning from below:—

a. Limestone, 38ft.[2]
b. Sandstone, fine grained, massive or flaggy, 40ft.
c. Limestone, 6ft.
d. Sandstone, 42ft.

In some places all these beds in their full thickness can be seen resting on the Whin. In other closely adjoining places we find the Whin has risen up almost vertically through the lower beds, *a*, *b*, and *c*. The sketch (Fig. 2) shows the Whin rising up near the limestone *a*. The locality which is sketched shows very clearly that the posts of limestone near the Whin are quite undisturbed—there has been no tendency for the Whin to lift them up with itself as it

Fig. 2. Basalt and saccharoid Limstone, "cheek by jowl," White Well, Cronkley Fell.
a Basalt, heather-covered. *b* Limestone, grass-covered

rises. That we get such oppositions of inclined Whin faces and edges of horizontal sedimentary beds cannot be accounted for by faults: in the first place we should frequently have to imagine faults almost circular, in the second we can sometimes see clearly that, when the Whin rises, it has resting on it higher beds than it had when it was on a lower level, a thickness of beds corresponding to the height of its rise being missing; in the third the Whin faces can usually be made out to be not fault faces, but original surfaces exposed by denudation.[3]

[1] This section is noticed and figured by Sedgwick in the paper already alluded to: he notices it as being specially interesting because:—1. The Whin is not parallel to the beds on which it rests. 2. The limestone has been altered into a saccharoid condition by the Whin. To these we may add: 3. Of the occurrence of Garnets, Prehnite, and Rutile (?) in the Whin, near its surface. 4. Of showing very well the bending round of the master joints in the Whin, as its base changes from a horizontal to an inclined position; the joints always keeping perpendicular to the base of the Whin.

[2] The limestone *a* is probably the top of the Melmerby Scar Limestone.

[3] That these surfaces are original is made out by—1. The extremely fine grain of the Whin. 2. The occurrence of Garnets and Pyrites, on or near them. 3. The presence of bits of altered rock clinging to them in places.

Going up the northern slope of Noon Hill, in Yorkshire, we have a section something as below, beginning from the bottom :—

a. Limestone, 100ft. (seen, there is probably more covered up by Drift, etc.)
b. Sandstone, 50ft.
c. Limestone, 20ft.
d. Sandstone, 8ft.
Whin.

If, from the top of the hill, we walk along the fell in a westerly direction for a few hundred yards, we find a great change. We can trace the thick sandstone running on, and we can see the limestone, *c*, coming on above it at the next elevation, but when we look for the thick limestone, *a*, we can find no trace of it—instead of the limestone we have a bed of Whin, with a thickness of probably 200ft. at least. This great mass of Whin has suddenly come in, in the space between us and Noon Hill, and yet the sandstone shows no evident signs of disturbance.

There are many irregularities in the Whin about Birkdale, in Westmoreland, and several cases where a Whin bed suddenly ceases entirely. In such cases we can often see the swallow holes, marking the tops of the limestones, going on in even lines, in spite of all the changes in the Whin below.

The above places may be taken as fairly representing what usually occurs in Teesdale when the Whin surface is irregular. I do not wish to go beyond the facts at all, nor to give any one the idea that there are no instances of mechanical disturbance in the Dale. There are probably such instances at the White Force, and at Skue Trods, both on the east side of Cronkley Fell, and Sedgwick mentions two (*op. cit.*) on the left banks of the Lune, near Lonton. But, in spite of these exceptions, I may safely say that the absence of mechanical disturbance is most striking. Of this I think we have corroborative evidence in the fact that there are no faults, or veins, known in the Dale, that do not go through the Whin equally with the sedimentary beds; all the ruptures known have been made subsequently to the formation of the Whin, there are none contemporaneous with it and made by it; in spite of all its irregularities, in thickness and position, it is not known to have once succeeded in actually breaking the beds among which it was thrust.

What does this general absence of disturbance mean? Suppose we get a horizontal bed of limestone or of sandstone gradually cut through by an inclined face of Whin. The question naturally arises, what has become of the bed, where it ends abruptly against the Whin face. It cannot have been compressed into nothing. It may have been broken up into fragments which have been carried away to a distance, and left as isolated pieces in the Whin, or it may be lying at the other surface of the Whin, or it may have been dissolved up by the Whin. As far as regards Teesdale I do not think the first supposition is at all a probable explanation of the facts, for I have not noticed any isolated fragments in the Whin; there may still, of course, be some, but those there are must be rare, whereas the explanation would require them to be numerous. There are sections showing thin beds of sandstone, etc., between Whin, but these beds would be found to be continuous with the mass of the sedimentary rocks of the country, if we could only trace them on, and are not fragments entirely surrounded by Whin (Q.J.G.S. vol. xxxi. No. 128, The Section at the High Force, Teesdale). According to the second supposition the beds have been disturbed by the irregularity of the Whin, though the effect of the disturbance is seen on the opposite side of it to that on which we see the irregularity. Fig. 3 represents the state of the case according to this supposition. Unfortunately, it is not usual to get sections showing both the top and bottom of the Whin, and I cannot say that the case may not be so at times, though I know of no evidence for it. But it does not seem at all satisfactory to have to suppose so

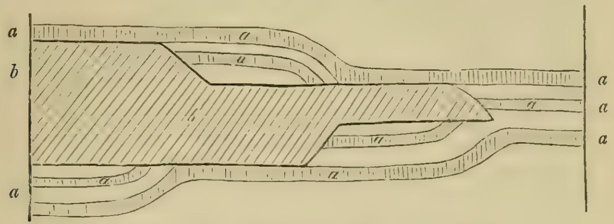

Fig. 3.—*a a* Sedimentary beds. *b* Basalt.

frequently that what we cannot see is different from what we can see, that the beds on the side of the Whin we cannot see have been disturbed, while those on the side we can see have not been disturbed. Moreover, in the case of an actual fracture of the beds, I think there would probably remain some indication of the tension which preceded it, *i.e.* the beds would show some tendency to assume a dip parallel to the Whin face, even if they had not actually done so.

Fortunately, we have in a few places much more direct evidence than mere absence of disturbance, to show that certain beds have been absorbed by the Whin. There are a few sections which show at once the bottom and top of the Whin, and the beds above and below, and so clearly that we may with certainty recognize these beds; and we can see in such cases that certain beds are missing where the Whin now is.

The best section of this kind that I know of is near Lodge Gill, in Westmoreland, on the side of the Tees about two miles above Caldron Snout. We have here three sykes, Cockle Syke, Rowantree Syke, and Lodge Gill Syke, falling into the Tees from the West; Cockle Syke lies E.S.E. from Rowantree Syke and is about 400 yards from it (at the points where we wish to compare their sections); Rowantree Syke lies in the same direction from Lodge Gill Syke, and is about 100 yards from it.

The sections in Cockle Syke and Rowantree Syke are as follows beginning from below:—

COCKLE SYKE.

a. Limestone.
30ft. shale; with occasional girdle beds; 4in. coal at top.
3ft. shale; with girdle beds.
17ft. sandstone.
30ft. strong sandstone seen near the top; signs of a little limestone coming in about 12ft. from the top.
b. Limestone.[1]

ROWANTREE SYKE.

a. Limestone.
3ft. calcareous shale.
14ft. altered shale.
21ft. Whin.
25ft. strong sandstone; rests apparently directly on the Whin; then strong girdle beds and sandstone; no shale.
5ft. limestone.
12ft. sandstone; thin flags in places.
b. Limestone.

In Cockle Syke the vertical distance between the two extreme limestones, *a* and *b*, is about 80 ft. In Rowantree Syke, if we include the Whin, the distance is the same; if we exclude the Whin, it is 59 ft. There can be no doubt that the limestones, *a* and *b*, are correctly correlated in the above sections. Also the section between these two limestones has wherever seen in the neighbourhood kept very constant, and is not likely to have changed greatly in the short distances between the sykes. We are then, apparently, entitled to conclude that in this instance, a thickness of sedimentary beds equal to the thickness of the Whin is missing where the Whin is. In Cockle Syke there is no Whin and we have the normal thickness of beds between the two limestones *a* and *b*; between Cockle Syke and Rowantree Syke a Whin bed has come in, which in Rowantree Syke is 21 ft. thick, and just this thickness of sedimentary beds is here missing.

In Lodge Gill Syke the section is not so clear; there are a good many small strings and veins about, and the beds are in places dipping rather high and variously. It would not be safe to place much dependence on the data derived from this syke alone. Nevertheless, the appearances are all in favour of there being still more sedimentary beds missing here than there are in Rowantree Syke, and at the same time the Whin bed in it is considerably thicker. The apparent section is as follows beginning from below:—

a. Limestone.
10ft. shale: very calcareous in places.
2ft. Whin.
3ft. shale.
41ft. Whin.
1ft. sandy shale.
2ft. hard fine-grained sandstone.
6ft. shale.
7ft. hard fine-grained sandstone.
4ft. limestone.
And then about 12ft. up to base of the limestone *b*.

Another instance of this kind, not on so large a scale, but more accessible, is to be seen at the High Force. I have already (Q.J.G.S. vol. xxxii. No. 128) referred to the fact that a 6 ft. Whin underflow can be seen starting from the base of the main Whin near the North end of the Force, and ending not far from the South end. The following diagram (Fig. 4.) represents roughly the changes that take place here. At the South end of the section the thickness of shale between the base of the main Whin and the top of the limestone is about 20 ft. In the middle of the section the total

[1] The limestone *b* is the second thick limestone below the Tyne Bottom limestone; it is about 130 ft. below it.

thickness of the shale present is about 14 ft. The shale layer which is immediately below the Whin at the South end can be traced running on, and we may be certain that it is no higher than the base of the main Whin in the middle of the section.[1] We will take this

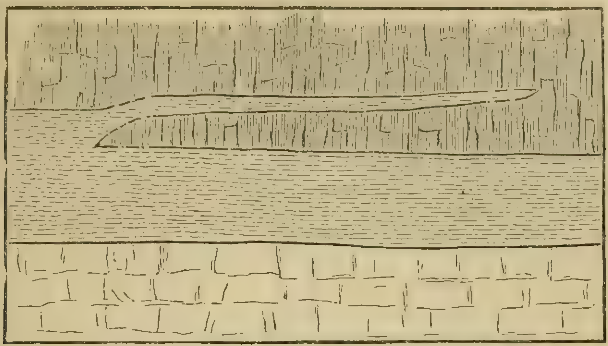

FIG. 4.—Diagram Section at the High Force.

a. Basalt. *b.* Shale. *c.* Limestone.

[Where the natural section is slightly obscure, the edges of the Whin are given in broken lines.]

shale layer as one geological horizon and the top of the limestone as another. Between these two horizons we ought to find the same sedimentary beds at any place in the section, because there is no sign of any change taking place in the character or thickness of the beds. Instead of this, we have at the South end of the section about 20 ft. of shale between these horizons, and in the middle only 14 ft. There is, therefore, 6 ft. of shale missing in the middle of the section, and we have just about this thickness of Whin instead of it.

An instance somewhat similar to the preceding two has been noted by my colleague Mr. D. Burns, in connexion with the "Little Whin Sill" of Weardale. He says (Proceedings of the North of England Institute of Mining and Mechanical Engineers, vol. xxvii. 1878, On the Intrusion of the Whin Sill) :—"In Weardale, what has been called the Little Whin Sill crops out from Rookhope to Stanhope, and it may extend much further eastward, between two posts of the Three Yard Limestone. This limestone is pretty uniformly of the thickness which its name implies, but where it includes the Whin, there is at some points only two feet of limestone on the top, and one foot below. This shows that the limestone is either abnormally thin, or that the Whin in some way has destroyed a fathom of it: the latter intepretation is certainly much more probable than the other."

I do not think that any theory of pre-existing fissures will help us to explain facts like these. Such fissures would have often to be of very large dimensions, to be inclined at all angles from vertical to horizontal, and to occur in all the sedimentary beds alike, in sandstone and shales as well as limestones. What agent could produce

[1] It is probably a little lower, because, as indicated in the diagram, the Whin base seems to have run down slightly towards the South in one place.

such fissures, and why is there no sign of there being, or ever having been, any, except where the Whin is? The only fissures that are known in the Dale are either small caves in the limestone, or fault fissures, and these last are generally approximately vertical and never very wide. The faults too, as has been already said, appear to be all posterior to the Whin, so that even the few fissures which do exist cannot be called in to help us.

I wish particularly to guard myself against being supposed to consider that all the Whin Sill has been made by the melting down of sedimentary beds. Some of the instances that I have noticed certainly seem to show that, in places, just the same thickness of sedimentary matter has been absorbed into the Whin, as the thickness of the Whin there present, but of course it does not follow that this is so generally, and in considering this question I wish to keep within the facts as strictly as possible. I do not say that the Whin Sill of Teesdale is wholly made up of sedimentary beds; I only say that in certain places certain sedimentary beds have gone to help to make it; and because this is so in Teesdale it does not necessarily follow that it is so in other districts. There might be particular reasons in Teesdale, arising either out of the character of the sedimentary beds or the heat of the intrusive mass, which caused more beds to be there dissolved up than in other places.

But if, on independent authority, it can be shown that similar beds of Whin in other districts have behaved in the way the Whin Sill of Teesdale is said have done, such evidence of course strongly confirms that collected here. Now of such confirming evidence there is no lack. I have already mentioned an instance from Weardale. I am informed by my colleague, Mr. J. G. Goodchild, that the excellent sections to be seen on the Pennine escarpment show clearly the same absence of disturbance by the Whin, and the same apparent loss of sedimentary beds where it puts on.

In reference to the "Whin Sills" of Scotland, Dr. James Geikie writes to me (Nov. 29, 1878):—"In the Dalmellington coal-field there are some very thick sheets of intrusive basalt-rock, which are persistent throughout the whole field. Thus in sinking for the black band ironstone the miners may pass through one or more sheets, or they may not encounter the thinnest squirt . . . . some of these were not less than 30 or 40 feet. Now, it was found that the occurrence of one or more of these beds in a shaft added nothing to the thickness of the strata. That is to say, that the distance between two well-known horizons (such as the black band and the coals at 50 or 60 fathoms above it) was not increased by the addition of the Whin floats. The manager of the ironworks and his engineer assured us that this held so true that in sinking a shaft they always got the ironstone at the estimated depth, no matter whether Whin-floats made their appearance or not. . . . . I have certainly seen cases where beds are without doubt entirely substituted by basalt. Thus seams of coal are occasionally quite eaten up and their place taken by 'white trap,' and I have seen the same in the case of a limestone band."

Mr. B. N. Peach, also, of the Geological Survey, informs me that in the Stirlingshire Coal-field, the Whin Sill which crops out from Denny to the Abbey Craig at Stirling eats up near Denny the lowest limestone and several fathoms of other beds, for a distance of three or four miles. That these beds had not thinned out previous to the intrusion seems clear from the limestone passing into the trap above and emerging from beneath it about four miles north from the place of disappearance, no limestone being found in the intermediate place. Figure 5 roughly represents the state of the case here.

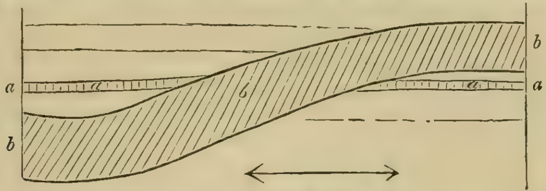

Fig. 5.—Diagram of the Whin Sill from Denny to the Abbey Craig at Stirling.
a. Limestone. *b*. Whin.

There is some suspicion of the same kind of thing in the South Staffordshire Coal-field. The following passage occurs in Jukes' memoir on this Coal-field, page 182:—"I was assured also by almost every one engaged in the works of this neighbourhood that, notwithstanding the variation in thickness of the 'green rock,'[1] there was no change in the total thickness of the measures; that, for instance, the thickness between the New mine coal and the Blue flats ironstone remained the same, whatever might be the variation in the 'green rock.' In other words it was affirmed almost universally that the 'green rock' not only intruded between the measures, but obliterated a mass of beds equal to its own thickness." He then, however, goes on to show by various pit sections that this statement certainly does not hold good for all places, and apparently concludes that any truth there is in it may be explained, either by the squeeze of the measures having been greater the greater the thickness of the basalt, or by a partial thickening or thinning of the basalt having in places happened to coincide with the reverse in the other beds.

The stratigraphical evidence, indeed, of the assimilation is so strong, and from so many different quarters, that I do not think it would be right to shut our eyes to it for fear of facing certain theoretical difficulties.

The main difficulty which at first presents itself is the chemical one. It is objected that the Whin is of very uniform chemical composition throughout, but that the beds which are supposed to have been absorbed are of very various composition—that in one place you suppose a great mass of limestone to have been absorbed, and in another place a mass of sandstone, and yet there is no trace in either place of there being so much extra CaO or SiO_2 in

[1] "Green Rock" is the local name for intrusive sheets of basalt in the South Staffordshire Coal-field.

the Whin. It would be a very laborious task to prove that the Whin is so uniform in composition as asserted, but I think that we may conclude that it probably is so, from its general mineralogical uniformity and the results of the few analyses that have been made of it. Some time ago I got analyses of two samples of Teesdale Whin executed in Dr. Percy's laboratory: one sample was taken from the top of Widdy Bank Fell, where I thought a mass of limestone had probably been absorbed by the Whin, and the other from the neighbourhood of Forest Church, where it seemed more likely that sandstone, shale, and limestone, in about equal proportions, had been absorbed. It will be seen from the appended details that the two samples are essentially the same chemically just as they are mineralogically :—

Basalt from Tinkler's Syke, top of Widdy Bank Fell.

		Composition per cent.
Silica		51·47
Alumina		16·48
Protoxide of Iron		8·49
Peroxide of Iron		3·61
Protoxide of Manganese		0·46
Lime		8·22
Magnesia		5·10
Potash		3·28
Soda		1·18
Iron Pyrites	Iron 0·08 Sulphur 0·09	0·17
Water	Hygroscopic 0·50 Combined 1·20	1·70
		100·16

Specific Gravity 2·82

Basalt from Teward's Bridge, near Forest Church.

		Composition per cent.
Silica		50·35
Alumina		16·80
Protoxide of Iron		8·36
Peroxide of Iron		3·51
Protoxide of Manganese		0·41
Lime		9·01
Magnesia		5·73
Potash		2·87
Soda		1·07
Iron Pyrites	Iron 0·037 Sulphur 0·043	0·08
Water	Hygroscopic 1·20 Combined 0·80	2·00
		100·19

Specific Gravity 2·84.

But any force which this objection possesses depends upon the assumption, that if sedimentary beds were taken up by the Whin they would remain in it close at hand to their original situation, whereas there may have been a very general circulation, both on a large scale and molecule by molecule, reducing all the parts of the mixture to a general uniformity of composition. The very possibility of forming alloys and of modifying the properties of metals by adding to them small portions of other substances depends upon this principle of circulation or diffusion, so that it cannot be said that we are without warrant for it. And, whatever theory of the formation of igneous rocks we adopt, it seems necessary to suppose that there has been in them such a circulation at some time or other, when they were in a molten state, for otherwise how can their uniformity of character over large areas be accounted for? We may suppose them to have been made at a time very far back indeed—to be contemporaneous with the "beginning of the world"—or we may suppose them to be of much later date; but in either case we must suppose that there was some kind of general circulation or diffusion through their mass bringing them down to an uniform composition, as far as consistent with their physical surroundings.

If we grant the probability of such a general circulation, and if we consider the immense area over which the Whin Sill is known to extend, and the still larger area over which it may be supposed to extend, both laterally and still more vertically, in connexion with some deep-seated mass, it does not seem a very likely thing that these devoured beds, when their material is distributed through the intrusive mass, should have much effect in altering its original composition. For large though these beds may, in some places, be, yet we must consider that they are not always of the same chemical composition; that sometimes they are of limestone, and sometimes of sandstone, and sometimes of shale, and sometimes of other rocks, and that it may well be that the sum total of the devoured beds when boiled down would produce a mass not much unlike that of basalt. For if the sedimentary beds are but the "ruins" of a primitive igneous mass, we must suppose that an average of them would represent fairly well the chemical constitution of this mass.[1] In a country where the beds among which the Whin lies are not very dissimilar to it in composition, and would of themselves make a rather fusible mixture, it would not be unnatural to suppose that there would be a greater tendency for them to be assimilated than in other countries; and this may be the reason why in Teesdale there seem to be such prominent cases of missing beds.

It may be objected in the second place that there is no trace of any passage in character between the Whin and the other beds, but that if it is true that these beds have been at times completely boiled down into Whin, we should expect frequent instances of their gradual passage into Whin. As a rule nothing could be sharper than the junction between the Whin and the sedimentary beds: it is like a knife edge. Near the Winch Bridge, and at a few other places, the junction specimens seem to contain irregularly alternating bands of Whin and of these beds, and it is not always easy to say which is which; but this is decidedly exceptional. This sharpness of junction is, however, to be seen in the results of nearly all chemical experiments, and is, I think, to be explained by the definiteness of character of chemical action.[2] Some molecules of SiO_2 or of $CaCO_3$, etc., have been absorbed by the basalt: these, we may suppose, have taken part in chemical reactions with certain constituents of the basalt, and have thus lost all outward likeness to their former selves. Other molecules have not combined chemically with any part of the basalt, but have only been induced by its heat to build themselves up in slightly different shapes from what they had before, and these still retain to a recognizable extent the chief of their old characters. And between these two sets of molecules a sharp distinction has thus been set up.

[1] It is true that if we simply regard the more ordinary sedimentary rocks, limestones, sandstones, and shales, we should find in them, when compared with most igneous rocks, a decided deficiency in the alkalies. But we have also to call to mind the great beds of Rock Salt ($NaCl$), Carnallite (KCl, $MgCl_2$, $6\,H_2O$), etc., which exist in many places.

[2] The late Rev. J. C. Ward has already, in reference to the Eskdale and Shap Granites, raised the question whether an altered rock may not have a sharply-defined margin (Q.J.G.S. vol. xxxi. No. 124, p. 592).

If the altered rock had been in its intimate composition of complicated chemical character, then, under the influence of the basalt's heat, its particles might have entered into fresh chemical combinations among themselves, and have assumed an appearance slightly resembling that of the basalt, and this resemblance might have been increased by the vapours ascending from the basalt. But the altered rocks in Teesdale are generally of comparatively simple character, are either good siliceous sandstones or fairly pure limestones, etc., and in their case the alteration by heat could have given rise to nothing greatly different in appearance from their unaltered representatives.

There are many quartz veins in the Dale which there can be no doubt have been formed in great part not simply by the growth of quartz in an open fissure, but also by the replacement of limestone by quartz along the sides of such a fissure. This is shown by the quartz vein stuff sometimes containing casts of crinoids, corals, etc. In other veins the ironstone contains similar casts, and must therefore have been formed by the replacement of limestone by the carbonate or peroxide of iron. And yet in both these cases the passage between the limestone which has been acted on and that which has not is sometimes so sharp—being comprised within an inch or so—that it may help us to conceive how igneous rocks may have sharp boundaries, and may still have been formed in part by the alteration of the beds whose place they occupy. I do not mean, of course, that these junctions are so sharp as those of the Whin, or that in other respects the cases are quite parallel, but, as far as regards our present consideration, the main differences between them are, I think, that the substances which replaced the limestone at once became solid and took up a fixed position at the moment they replaced it, while in the case of the igneous rock the replaced and the replacing substance continued to form together a fluid mass.

I am conscious that the explanations I have attempted of these difficulties are only very crude, and I must leave it to others to find out more satisfactory ones. I fully admit the sharpness of the junctions and the general uniformity of composition of the Whin as much as any one. The question is not as to their existence, but as to their value. And in settling this it seems to me that the broad physical evidence in the field is of paramount importance. Whatever this evidence clearly points to we ought to accept. There may be difficulties facing us, but if we have made quite certain of our facts to begin with, we may be sure that these difficulties are only apparent, and will in time be cleared away.

If it be granted that there is nothing impossible or unusual in these sheets of basalt eating up the beds among which they have been thrust, it will be necessary also to allow this power to various other intrusive masses. The same intrusive mass will, according to the circumstances surrounding it, sometimes take the form of a sheet and sometimes of a boss and sometimes of a dyke. There can be little doubt that it will continue to have essentially the same properties and powers through all these comparative accidents of form. When it is in the form of a dyke, or of a boss, we cannot see so clearly what the physical relations between it and the surrounding beds are as we can when it is in the form of a sheet, for it is only in the latter case that we have our sections inclosed between definite and recognizable horizons—between a top and a bottom. Yet there are not wanting indications of assimilating power derived directly from dykes, as is shown by the following remarks made by Professor Hughes on the mica trap dykes of the neighbourhood of Kirkby Lonsdale and Sedbergh (Geol. Survey Memoir, 98 S.E., pp. 41-42):—"They do not appear to displace but to replace portions of the rock in a manner that would suggest that portions of the sedimentary rock had been assimilated to the mica trap. The edges of the beds are not broken off or pushed aside as one might expect would be the case were a viscid molten mass squirted violently into the sedimentary rocks, and the opposite walls of the dyke often do not correspond as they should do if the molten mass quietly filled an open fissure, and moreover, when the rocks can be examined in the neighbourhood of the dykes, such fissures do not appear. It may be worth consideration whether in some cases it might not be possible that the action of gases or of hot water holding minerals in solution, communicating along lines of fissures with the joints, might produce the phenomena observed."

And I think it is scarcely necessary to add that many large granitic or syenitic masses, even though sharp junctions are commonly found round their margins, show still more striking instances of absence of disturbance.

APPENDIX.

I have thought it worth while to make a rough estimate of the kind of mixture we should get if we imagined the rocks which occur in the neighbourhood of the Whin Sill in Teesdale to be melted down in about their natural proportions.

A very common position for the Whin is about 20ft. below what is called the Single Post Limestone,[1] and I think that we might take the 200ft. of beds which usually come below this horizon as a fair type of the rocks among which the Whin occurs generally. This 200ft. is made up something as below, beginning from the top :—

Shale	32ft.
Limestone (Tyne Bottom)	32ft.
Mainly Sandstone	20ft.
Limestone	4ft.
Shale	10ft.
Sandstone	40ft.
Limestone	26ft.
Shale and Sandstone in about equal proportions	30ft.
Limestone	7ft.

Or we might say that we have roughly in this 200ft., 70ft. of limestone, 70ft. of sandstone, and 60ft. of shale.

To show the composition of the limestone a specimen of the Tyne

[1] Curiously enough it is never once seen in the Dale immediately below the Tyne Bottom Limestone, although this is the position ascribed to it by those who advocate its contemporaneous character.

Bottom limestone was taken from the Bands Mine, Harwood, and was found to have the following composition :—

Lime	53·87
Magnesia	1·20
Alumina	0·35
Protoxide of Iron	0·11
Protoxide of Manganese	0·06
Silica	0 78
Carbonic Acid	43·27
Sulphuric Acid	0 19
Organic matter	0·33
	100·16

Specific gravity 2·67

A specimen of sandstone occurring immediately below this limestone, and from the same locality, had the following composition :—

Silica	95·55
Alumina	2·30
Peroxide of Iron	0·25
Lime	0·80
Water	0·15
Carbonic Acid	0·88
	99·93

Specific gravity 2·57

A specimen of shale occurring immediately above this limestone, and taken from the neighbourhood of Moor House, Garrigill, had the following composition :—

Silica	48·30
Alumina	29·69
Protoxide of Iron	5·98
Protoxide of Manganese	0·07
Lime	0·66
Magnesia	1·79
Potash	3·96
Soda	0·39
Phosphoric Acid	0·12
Water { Hygroscopic 2·70, Combined 6·70 }	9·40
	100·36

Specific gravity 2·62

Calculating the chemical composition of the 200ft. of beds from these data, we find that it should contain in 100 parts :—

Silica	48·206
Alumina	9·835
Iron Protoxide	1·832
Iron Peroxide	·612
Protoxide of Manganese	·042
Lime	19·332
Magnesia	·957
Potash	1·188
Soda	·117
Water	2·883
Phosphoric Acid	·036
Organic matter	·116
Carbonic Acid	15·477
Sulphuric Acid	·066

And should be of specific gravity 2·62.

If the mixture were melted down, the carbonic acid and the organic matter could, I suppose, scarcely remain in it; the water and the sulphuric acid might also be driven off in part. The proportion of iron in the mixture would be rather greater than that calculated, as in certain parts of the section the shale contains bands of ironstone nodules, and the sandstone is not always so quartzose as the specimen analyzed.

II.—Notes on the Vertebrata of the Pre-Glacial Forest Bed Series of the East of England.

By E. T. Newton, F.G.S.

(*Continued from p.* 427.)

PART III.—UNGULATA.

In my first communication on the *Carnivora* I gave, at the commencement, a list of all the species said to have been found in the "Forest Bed," and then at the end a corrected list. The same course will be followed in the present instance, so as to show at a glance, those species which have been removed and those which have been added to the list.

Ungulata said to have been found in the "Forest Bed Series." (See also corrected list, at p. 452.)

Equus fossilis.	*Cervus ardeus.*
—— *caballus.*	—— *bovides.*
Asinus fossilis.	—— *capreolus.*
Rhinoceros etruscus.	—— *carnutorum.*
—— *leptorhinus.*	—— *dama.*
—— *megarhinus.*	—— *elaphus.*
—— *tichorhinus.*	—— *Gunnii.*
Hippopotamus major.	—— *latifrons.*
Sus scrofa.	—— *martialis.*
—— *arvernensis.*	—— *megaceros.*
Bos primigenius.	—— *Polignacus.*
Bison priscus.	—— *Sedgwickii.*
Ovis.	—— *verticornis.*
Capra.	—— *tarandus.*
	(Axis.)
	(Rusa.)

Equus.—The Equine remains found in the "Forest Bed" were referred by the earlier writers to the same species as the recent Horse, *Equus caballus*; but in 1846, when Prof. Owen separated certain fossil forms under the name of *E. fossilis*, some of the "Forest Bed" specimens were referred to it. More recently, the numbers of teeth obtained have shown that the variations are even greater than was supposed, and palæontologists have found it impossible to separate the Post-Pliocene Horse teeth from the recent forms, by any constant character. Moreover, a study of the teeth of the recent Equine species (*vide* Owen, Phil. Trans. 1869, vol. 189, p. 517, and Rütimeyer, Abhand. d. schweiz. pal. Gesell., 1875, vol. ii.) teaches us how extremely difficult, if not impossible, it would be to distinguish isolated teeth. Rütimeyer is of opinion that the Equine remains, found in the river-gravels and caves, cannot be specifically separated from the recent Horse (*vide* Beitrag. z. Kenn. de foss. Pferde., Verhand. d. naturf. Gesell. in Basel, Band iii. Heft 4, 1863), and he proposed to call them *Equus caballus fossilis*. Among the Continental Pliocene forms he also found teeth which, being indistinguishable from the recent Horse, he also referred to the above species. Certain of the Pliocene Horse's teeth, however, are distinguished by having the inner pillar of enamel in the upper teeth, smaller, more rounded, and more separated from the rest of the tooth, than is the case in the recent or Post-Pliocene forms, and for these he proposed to retain the name of *Equus fossilis*; subsequently, however (Weitere Beiträge, etc., Abhand. d. schweiz. pal. Gesell., 1875, vol. ii.), he thought it well to adopt Prof. Cocchi's name of *Equus Stenonis*, which had been proposed by the latter gentleman for teeth of a similar character (L'Uomo fossile nell' Italia centrale, Milano, 1867, p. 18).

The greater number of Horses' teeth from the "Forest Bed," which have come under my notice, I cannot separate from those of the recent Horse, and, adopting Prof. Rütimeyer's convenient nomenclature, refer them to *E. caballus fossilis*. Among the upper molars, however, a few examples are to be found, in which the inner pillar of enamel is smaller, more rounded, and more separated from the rest of the tooth, than in any recent Horse's tooth, and, in fact, resembles so closely the forms figured by Rütimeyer, and called *E. Stenonis*, that I feel compelled to refer them to that species. If I am correct in this determination, then we shall have to recognize two species of horse in the "Forest Bed," *E. caballus fossilis*, Rütimeyer, and *E. Stenonis*, Cocchi.

Asinus fossilis.—Mr. A. Bell includes the Ass as a "Forest Bed" species, but I have failed to find any specimens undoubtedly from the "Forest Bed," which could be referred to this species. The small equine teeth in the King Collection are of very uncertain origin.

Rhinoceros.—Although the earlier writers on the "Forest Bed" fauna thought they had recognized *R. tichorhinus* and *R. leptorhinus*, yet of late years it has been generally acknowledged that neither of these species occur; the remains so named being referable to the *R. etruscus*, a species established by Dr. Falconer, in 1858 (Pal. Mems. vol. ii. p. 354), and described by Prof. Boyd Dawkins in 1868 (Q.J.G.S. vol. xxiv. p. 207). Nearly all the *Rhinoceros* teeth from the "Forest Bed" are characterized by the more or less strongly developed guard, which is one of the specific peculiarities of *R. etruscus*, and there can be no question as to their belonging to that species. In Mr. Gunn's Collection there is an upper fourth premolar tooth, which was referred by Messrs. Lartet and Falconer, after long consultation, to the *R. megarhinus* of Christol. These gentlemen, it appears, had some doubts about this tooth, but thought it more nearly allied to the last-mentioned species than to any other. A comparison of this tooth with the *Rhinoceros* remains in the British Museum leads me to the same conclusion; but, as there is still some uncertainty, I place a note of interrogation after the species.

Hippopotamus.—The Hippopotamus remains from the "Forest Bed" were referred by Prof. Owen, in 1846, to his *H. major*; and there is no reason for thinking that any of the specimens, more recently obtained, represent a second species; on the other hand, it is open to question, whether the fossil *H. major* is specifically distinct from the recent *H. amphibius*. For the present it seems to me best to retain the name of *H. major*.

Sus.—The Pigs' teeth preserved in the Green Collection at the British Museum, and alluded to by Prof. Owen (Brit. Foss. Mams. p. 429), are without doubt the same as the recent *Sus scrofa*. A fragment of a last molar tooth in the King Collection, at the Museum of Practical Geology, is certainly a portion of a very large tooth, and may have belonged to another form; but it would be unwise to attempt to refer it definitely to any species. I see no reason whatever for referring this or any other "Forest Bed" specimen to the *Sus arvernensis*.

Bos or Bison.—*Bos primigenius* and *Bison priscus* have both been given as "Forest Bed" species. Numerous bovine remains have been obtained; but at present I have been unable to find any specimens of the skull with horn-cores, without which, it seems to me, one cannot speak with certainty. Prof. Boyd Dawkins is of opinion that some of these remains may be recognized as *Bos primigenius*. I cannot feel the same certainty; but it will perhaps be best to retain this name and to indicate the uncertainty, as in other cases, by a note of interrogation.

Ovis or Capra.—Mr. A. Bell includes these in his list of "Forest Bed" Vertebrates, but so far as I can find, the determination rests upon some bones found by Mr. Gunn, the age of which is so uncertain, or rather it is so extremely probable that they are of much more recent origin, that they must be omitted.

Caprovis Savinii, new species.—Mr. A. Savin, of Cromer, possesses a fine horn-core and frontal bone from the "Forest Bed" near Cromer, which has evident affinities with both the Sheep and the Goat; but differs from both. The horn-core is compressed, spirally twisted, and directed outwards and backwards; the spiral twist being in an opposite direction to that which obtains in the Sheep. The nearest living ally of this interesting fossil appears to be the Wild Sheep of Sardinia, the direction of the horn-cores being as nearly as possible the same, but their form is different, being in section subtriangular in the Sardinian Sheep, but spindle-shaped in the fossil. Under these circumstances, one can hardly do otherwise than refer this fossil to the same genus as the Sardinian Sheep, namely, *Caprovis*; but the differences being such as to prevent their being looked upon as specifically identical, I propose to name it after its possessor, *Caprovis Savinii*.

Cervus.—This genus is represented by a much greater diversity of species than any other occurring in the Forest Bed Series. No less than fourteen species have been recorded from this horizon, and, large as this number may appear, it is certain that several new forms have been found which have yet to be determined or described. It will perhaps be best to consider each species separately.

C. bovides, Gunn, MS.—Mr. Gunn has given this name to a very remarkable cervine frontal bone and portion of antler; the latter springing from the side of the skull nearly at right angles to it, and curving downwards, slightly decreases in size, thus giving it a very bovine aspect.

Cervus capreolus, Linn.—I have only been able to trace one specimen of this species; it is a nearly perfect antler preserved in the King Collection (M.P.G.). There is no doubt as to this belonging to *C. capreolus*, and it is labelled as having been obtained from the Forest Bed at Hasboro, low-water.

Cervus carnutorum ? Laugel.—Professor Boyd Dawkins, in 1872 (Q.J.G.S. vol. xxviii. p. 408), described certain cervine remains from Norfolk and Suffolk, which he referred to the *C. carnutorum* of M. Laugel. These specimens were two frontlets, and a base of an antler, and I think there is little doubt Professor Dawkins is correct in his determination; but as regards the horizon from which they were obtained there is some uncertainty; the one from the Norfolk "Oyster Beds" is of necessity not to be depended upon; and the other specimen, which is in the Chichester Museum, is said to have been obtained from the Forest Bed at Easton, Suffolk, at which locality my colleague, Mr. J. H. Blake, informs me it is, to say the least. extremely doubtful whether the true "Forest Bed" occurs.

Cervus Dawkinsi, n. sp.—This name is proposed for the smaller specimen figured by Professor Boyd Dawkins as *C. verticornis;* but which, on account of the flattened form of the brow-tyne, its close approximation to the burr, and its being given off in quite a different plane from that of *C. verticornis*, it is thought necessary to separate from that species. *C. Dawkinsi* in general appearance has much affinity with *C. Fitchii*, Gunn, MS., but is distinguished from that species by the presence of a brow-tyne close to the burr, and passing off in the same plane as the second tyne. This specimen is in the King Collection in the Museum of Practical Geology.

Cervus elaphus? Linn.—It is very uncertain as to whether this species has ever been obtained from the "Forest Bed." Dr. Falconer did not recognize it, and although it has been very generally included in lists of "Forest Bed" species, I have been unable to trace any undoubted specimen from this horizon. It is just possible that some basal portions of antlers which have been found may belong to this species, and therefore it seems best to retain the name with some doubt.

Cervus etueriarum ? Croizet and Jobert.—Dr. Falconer, in his Pal. Mems. p. 479, refers a portion of an antler in the King Collection to the genus *Rusa*. This specimen very closely resembles the examples of *C. etueriarum*, Croizet and Jobert; and *C. cylindroceros*, Dawkins, which are preserved in the British Museum, but is rather larger and more curved than either; on the whole, it is most like the *C. etueriarum*, to which it is proposed to refer it provisionally.

Cervus Fitchii, Gunn, MS.— Mr. Gunn has kindly sent me an engraving of an antler in Mr. R. Fitch's Collection, which he is about to describe under the above name. It is evidently related to the *Megaceros* type, and closely resembles the form above called *C. Dawkinsi*, but it has no brow-tyne close to the burr and in the same plane as the second tyne, such as is found in the latter species.

Cervus Gunnii, Dawkins, MS.—This name has been proposed by Prof. Boyd Dawkins for a portion of an antler in the King Collection, which resembles, so far as preserved, the antler of *Cervus megaceros*, but without any brow-tyne. I should have preferred to regard this, provisionally, as belonging to *C. megaceros*, but, as the name has more than once appeared in print, it is thought best to retain it. It is from the "Forest Bed" of Mundesley.

Cervus latifrons, Johnson.—Mr. Randal Johnson has proposed this name for a remarkable antler in his collection (Ann. and Mag. Nat. Hist. ser. iv. vol. xiii. 1874). The broad frontal bone, from which the antler springs almost at right angles, the absence of a brow-tyne, and the presence of a large curved tyne on the front of the beam at about 12 inches from the burr, are the more important characteristics of the species. It was obtained from the "Forest Bed" exposed at low water at Hasboro.

Cervus megaceros ? Hart.—This species is included as a "Forest Bed" form by almost all writers on the subject. Notwithstanding this, I have been unable to find any undoubted specimen from this horizon. The antler now called *C. Gunnii* seems to have been regarded as possibly a young *C. megaceros* by Dr. Falconer; but I am disposed to think that the name must have rested upon the dredged specimen referred to by Prof. Owen, and upon others now called *C. verticornis*. I am unable at present to say definitely whether the species does or does not occur in the "Forest Bed."

Cervus Polignacus, Robert.—Dr. Falconer, in 1863, referred a specimen in Mr. Gunn's Collection to this species (*vide* Pal. Mems. vol. ii. p. 479). So far as preserved it agrees with M. Robert's description; the brow-tyne being almost in a line with the beam. Mr. Gunn's specimen was obtained from the "Forest Bed" at Mundesley.

Cervus Sedgwickii, Falconer.—The remarkable antler in Mr. Gunn's Collection, which was described by Dr. Falconer under this name (Pal. Mems. vol. ii. p. 471), is so well distinguished by its flattened form, and by its tynes being only on one side of the beam, that it will merely be necessary to add, that it was obtained from the "Forest Bed" at Bacton.

Cervus verticornis, Dawkins.—The portion of an antler which Dr. Falconer called "Mr. Gunn's large *Strongyloceros*" (Pal. Mems. vol. ii. p. 479) was redescribed by Prof. Boyd Dawkins as *C. verticornis* (Q.J.G.S. 1872, vol. xxviii. p. 405), but he included with it a small antler in the King Collection, which it is now proposed to separate as a distinct species (*vide C. Dawkinsi*). The larger specimen, and many others more recently obtained, which may for the present be included in the same species, are evidently closely allied to the *Megaceros* type, but are characterized by the large round brow-tyne, given off from the inner and upper part of the beam quite in a different plane to the second tyne, some distance from the burr, and curving forwards and downwards until it assumes the vertical direction on account of which the species was named *C. verticornis*. Specimens answering to this description have been obtained from the "Forest Bed" at Pakefield, Overstrand near Cromer, and Mr. Savin has one from the Black Bed at West Runton.

The following *Cervidæ* will have to be removed from the "Forest Bed" lists, for reasons given below.

Axis.—Dr. Falconer included this genus in his list of Forest Bed and Norwich Crag species, but I can get no clue to the specimen, and must therefore omit the name, as it may have been from the Crag.

Cervus ardeus, Croizet and Jobert.—A portion of an antler in Mr. Gunn's Collection is called *Cervus ardeus*, apparently on Dr. Falconer's authority; but it does not agree with any of the figures given by MM. Croizet and Jobert, and cannot be referred to that species. Prof. Boyd Dawkins has omitted the name from his latest lists, and one cannot well do otherwise.

Cervus Dama, Linn.—No true *C. Dama* is known from the "Forest Bed." The determination appears to have rested upon fragments which in all probability belong to other species.

Cervus martialis, Gervais.—The specimens which were referred to this species appear to have been portions of antlers similar to those subsequently called *C. Sedgwickii*, by Dr. Falconer, and the species cannot therefore be regarded as a "Forest Bed" form.

Cervus tarandus, Linn.—I have been unable to trace any specimen referable to this species, and it seems to have been a mistake, for it only appears in Sir C. Lyell's third edition of the "Antiquity of Man," and is omitted from the later edition in 1873.

List of the Ungulata of the "Forest Bed Series" corrected in accordance with the above notes.

(Those marked with an asterisk are new to the "Forest Bed Series.")

Equus caballus fossilis, Rütimeyer.
* ,, *Stenonis*, Cocchi.
Rhinoceros etruscus, Falconer.
,, *megarhinus ?* Christol.
Hippopotamus major, Owen.
Sus scrofa, Linn.
Bos primigenius ? Cuvier.
* *Caprovis Savinii*, Newton, n. sp.

Cervus bovides, Gunn, MS.
,, *capreolus*, Linn.
,, *carnutorum ?* Laugel.
* ,, *Dawkinsi*, Newton, n. sp.
,, *elaphus ?* Linn.
* ,, *etueriarum ?* C. & J.
* ,, *Fitchii*, Gunn, MS.
,, *Gunnii*, Dawkins, MS.
,, *latifrons*, Johnson.
,, *megaceros ?* Hart.
,, *Polignacus*, Robert.
,, *Sedgwickii*, Falconer.
,, *verticornis*, Dawkins.

In addition to the above, there are, scattered through different collections, some eight or ten distinct forms of Cervine antlers, which have yet to be determined.

III.—Woodwardian Laboratory Notes.—North Wales Rocks.

Contributed by E. B. Tawney, M.A., F.G.S.,
Woodwardian Museum, Cambridge.

Part II.

(*Continued from the May Number*, p. 215.)

Diabase-porphyrite—from hill designated as a Trigonometrical Station $1\frac{1}{2}$ mile N.N.E. from Pwllheli: the hill is quarried for road metal; a good hand-specimen is easily obtained; it has a dark-green ground with porphyritic felspars up to $\frac{1}{4}$ inch long of pale greenish colour; a little pyrites; very slight effervescence with acids.

Microscope.—The large felspars are streaky, and show remains of banding, but are nearly entirely decomposed, partly to diverging zeolite needles, and partly to granulated similar matter; some of the smaller prisms show bright-coloured bands, but grey tints are more common.

The augites have a tendency to collect together into grouped crystals, they are fresh, and polarize brightly; they contain many apatite prisms. There are numerous tracts of pale green viridite, with radiate arrangement of a fibrous structure, showing aggregate polarization; some tracts are colourless zeolites in the centre, with similar structure, and surrounded by a viridite border. The green areas are also full of little spherical concretions of yellowish-brown matter as a nucleus, with a clear border of colourless matter showing aggregate polarization. Black iron oxide present is apparently titaniferous. The apatite, abundant in the augite, is somewhat decomposed. The rock might probably be called a Labrador-porphyry.

The Geological Survey have not attempted to separate the felsites from the diabases and other igneous rocks in this district by distinct colours, but have occasionally placed on the map P. or F.P. for Felsite-porphyry, or as in this case G.P. for greenstone-porphyry. In Prof. Ramsay's Memoir on N. Wales, p. 174, we read: "North and north-east of Pwllheli as far as Plas Du, there is a broad strip of rock in two places alternating with slaty bands. It hovers in character between a greenstone and a felspar-porphyry. At the trigonometrical station it consists of large crystals of felspar imbedded in a hornblendic-looking base [*sic*]. Associated with this rock, about three-quarters of a mile west of Pwllheli, there occurs the only rock in Lleyn of an ashy or brecciated character." The last statement requires a little qualification perhaps. We are not quite disposed to agree with the idea of the diabases passing into the felsites, as we saw no such passage; though they occur close together, they are even then quite distinct, as far as we have seen. The diabases seem to crop out in a series of bosses along the line mentioned above, are separately intrusive, and probably later than the felsites.

[P. 63–68.] Labelled "varieties of trap from one mile N.W. of Pwllheli, near Deneio," include two felsites and two diabases; one of the latter [P. 63–64] is a coarsely crystalline rock with large augites; the hand-specimen shows the felspars much altered; there are concretions of secondary formation up to $\frac{1}{2}$ inch diameter, zeolites and calcite, with an outer border of yellow epidote. I do not know the exact point from which Sedgwick collected this variety, and they were not sliced. These bosses seem intrusive through the felsite. The following one I collected in a quarry midway between farms of Ffrith and Henllys on the map, half a mile N. of Pwllheli; close by is seen the felsite.

Diabase, N.W. of Ffrith, Deneio, in the mass shows an imperfect columnar structure with spheroidal exfoliation near the top of the quarry. A dark-green rock, which breaks frequently into flaggy pieces, the fractured surfaces with velvety serpentinous coat; this arises from the veins of chrysotile having a roughly parallel direction; they cut straight through the ground, and the augites. The microscope shows these veins of rhombic chrysotile to constitute an important fraction of the rock; they are not all parallel. The augite is pretty fresh in its normal condition, but some of it is full of bundles of curved capillary lines, mostly parallel in two intersecting directions, so crowded as to render the augite quite fibrous-looking; they seem to me minute cracks rather than fibres, the slenderer ones exceedingly delicate. There are lines of brownish elongated inclosures, three or four deep, occasionally present, which seem in no fixed relation to the prismatic cleavage. The plagioclase prisms retain their striations, but many are decomposing; patches of granulated zeolitic matter covering a considerable part of the slide have no doubt been formed from them, some radiating and showing bright aggregate polarization. There are also greenish and dirty brownish green tracts due to decomposition of the augite probably; the green areas where fibrous show bright aggregate polarization; the dirty grains with ferruginous staining are probably another part of the same process.

[P. 71.] *Gimblet Rock* (Carreg y rimbill), Pwllheli.—This rock, which forms a boss at the entrance of the harbour terminating the sand-hills, is largely quarried for "sets"; its divisional planes have been noticed by Professor Bonney (Q.J.G.S. vol. xxxii. p. 145). In the hand-specimen it is a speckled brown and white rock of medium grain, owing to the large sheets of bronzy pyroxene, with cleavage planes of metallic lustre, being interrupted and penetrated by the numerous felspar crystals which protrude in all directions through them. Abundant effervescence with acid. From the nature of the pyroxene it must be classed as a diabase.

Microscope.—The pyroxene is in large sheets, interpenetrated by the felspars; it is pale yellow in the slice; the cleavage not very constant, and not pinacoidal. A most noticeable feature are lines of minute inclosures, which, when magnified 400 diameters, are seen to be minute grains of irregular form and yellowish ferric colour; these being several deep form broad lines which cross the cleavages at all angles, apparently, according to the direction of the slice; they are undulated, sometimes branching, but usually roughly parallel to each other,—it is better developed here, but the same feature as in the slides [P. 58], and that from Deneio: only where the augite is fibrous from incipient decomposition does it simulate diallage; from this stage it passes to a clear feebly dichroic chloritic mineral, and then into an irregular fibro-granulated dirty green substance, with aggregate polarization. The plagioclase is partly fresh, but the centres of most of the crystals are converted to a white opaque substance; they are much traversed by viridite veins in places. A little brown mica, strongly dichroic, is present; some flakes, apparently in the centre of decomposed augite, point rather to its derivation therefrom; others connected with crystals of black iron-oxide do not show so plainly any relation to the augite: the iron-oxide from its form seems probably ilmenite, but is free from white incrustation. A little secondary quartz crystallized out in a few spots. Professor Ramsay (Mem. Geol. Surv. vol. iii. p. 173) speaks of it as a rock in which "the hornblende rather predominates over the felspar."

[P. 119.] *Quarries, N. Base of Carn Fadrin, near Cefn Madrin.*—Identical in appearance with the Gimblet Rock and [P. 58] : plentiful effervescence with acid. The microscopical examination shows only slight differences from the above-mentioned rocks. The augite has the same characters ; in some crystals bands of ferric-oxide-like inclosures made up of detached grains cross the prismatic cleavage irregularly. Besides the augite, there are flakes of a dichroic mineral, sometimes brown, sometimes pale green ; when placed with the cleavage parallel to the short diagonal of the lower Nicol, it has all the outward appearance and prism angle of hornblende, but in each case the maximum extinction angle was 35° in a clinodiagonal section, which differs from normal hornblende ; it must be probably derived from the augite ; the green is apparently a further change from the brown, as the latter shades off into it in some patches.

There are also a few flakes of brown mica strongly dichroic. The felspars are mostly decomposed interiorly into an opaque white matter. The decomposition products are the same as in the preceding slide, viridite patches, calcareous specks, fibrous aggregates, etc.

We may call the rock a proterobase, using the word in a petrological and not a geognostical sense. In the present rock the hornblende is far inferior in amount to the augite ; in the preceding case it was absent, but in some of the following it predominates over the augite. These hornblendic diabases are now noted in several parts of the Lleyn promontory, viz. near Aberdaron, Nevin, Pwllheli, and Clynnog.—E. B. T.

[P. 58.] *Quarry in the Nevin Hills,* used for building purposes. This rock, which is of a brownish colour, speckled with white, is identical in the hand-specimen with that of Gimblet Rock Pwllheli [P. 71], which has been incidentally mentioned as a gabbro (Q.J.G.S. vol. xxxii. p. 145). Though to the eye like a gabbro, the microscope characters of the pyroxene are nearer to augite, and it is therefore classed as diabase : the felspathic portions effervesce with acid.

Microscope.—This slide shows a coarsely crystalline aggregate of intercrystallized plagioclase, felspar and pyroxene. The plagioclase, though still showing in some places its characteristic twinning, is generally much decomposed, being kaolinized in parts. The pyroxene occurs in large irregular masses, whose edges are generally defined by plagioclase crystals, which often protrude into and are contained within it : though much cracked, it is well preserved and gives rich tints with polarized light. A third substance is also present, consisting apparently of aggregated chloritic and serpentinous minerals : from the external shape of these pseudomorphs one would conjecture them to have replaced pyroxene, but if so two varieties of that mineral of different durability must have been formerly present. Irregular grains of iron peroxide are scattered throughout the slide, some of which are partly-decomposed ilmenite. There is a little calcite and a few microlithic needles of what may be apatite: the slide also contains a few grains apparently of quartz and of secondary origin.

[P. 65.] Variety of trap one mile N.W. of Pwllheli, near Deneio on map. A dark green rock of coarse grain, with brown-black augite and white or green felspars: no appreciable effervescence with acid.

Microscope. — A coarsely crystalline rock. Plagioclase felspar occurs in long oblong crystals very much decomposed and presenting a "saussuritic" aspect: intercrystallized with it is a good deal of augite rather more decomposed than in P. 58. Two or three secondary products of chloritic nature are present here: one, the more serpentinous variety of viridite: another, possibly chlorite or a doubly refracting mineral of a serpentinous nature. There are irregular grains of iron peroxide, nearly all of which seem to be decomposed ilmenite, scattered throughout the slide. There are also five or six polygonal grains of a zeolite, apparently not orthorhombic, possibly heulandite. The rock may be called a diabase, but has evidently been a dolerite.

[P. 126.] Near Pwllheli, "near the junction of the N. road with the turnpike;" the turnpike indicated is probably about a mile on the Carnarvon road. The rock is brownish-grey, of medium grain, with blacker spots: very slight effervescence with acid.

Microscope.—The ground consists of intercrystallized plagioclase and augite, and a third olive-green mineral in very variable-sized grains. Most of the plagioclase is fairly well preserved, except that it shows some decomposition along its principal cleavage planes and appears to be traversed by strings of viridite. The augite is in a good state of preservation, and shows in many cases transverse sections of the prism with the characteristic cleavages. The third chloritic mineral occurs similarly to the augite and has the same appearance as in [P. 65]. In one part of the slide there are several grains of a zeolite rather resembling those in [P. 65], and it is noticeable that in the vicinity of these the plagioclase has undergone a "saussuritic" decomposition. There are irregular grains of iron peroxide scattered throughout the slide, and a few specks of pyrites.

The rock has evidently been a basalt, but would now be called a diabase.

[P. 88.] *Diabase,* Porth Vogo, "close to junction." The locality cannot be identified on the Ordnance Map, but from perusal of Sedgwick's Journal, it is apparently from near Llanfaelrhys, the junction being with the shales of that district. It is a grey rock of fine grain, and contains numerous spots of calcite about $\frac{1}{8}$ inch diameter, showing the cleavage planes: even the light grey ground effervesces most actively with acid.

Microscope.—The ground in the slide consists of small plagioclase crystals and a translucent green mineral: throughout this is scattered a very large amount of iron peroxide, a great deal of which is ilmenite. The plagioclase is well preserved and shows its characteristic twinning. The green mineral is feebly dichroic and doubly refracting with a slightly fibrous structure; it occurs in scales and larger masses, in which latter case it is associated with epidote and probably replaces augite. There are several large amygdaloids of calcite in this slide, one of which contains near its edge five or six well-defined hexagonal quartz crystals.

The rock is now a diabase, and was once probably a vesicular basalt.

[P. 12.] *Third trap dyke between Nevin and Porth Dinlleyn.*—The hand-specimen shows a good deal of pyrites; it is a dark green rock of medium grain, the constituents not marked out by any great difference of colour: abundant effervescence with acid.

Microscope.—Consists of very much decomposed plagioclase and augite. The plagioclase has undergone a "saussuritic" decomposition, and the augite is traversed by cracks which are lined with decomposition products. Anastomosing veins of isotropic viridite permeate the whole slide. There is some calcite present, and a great many grains of iron peroxide, the chief part of which is ilmenite, are scattered throughout the slide. The rock is a diabase.—A. S. Reid.

[Cl. 15.] *Hornblendic diabase*, "tumbled" block under Gyrn Goch, near Clynnog; a greenish to brownish-black rock, coarsely crystalline, with bright cleavage planes of bronze-coloured bisilicates; there is an absence of any white material; no effervescence with acid noticeable. Copper pyrites grains are seen in it.

Microscope.—This rock is crystalline in structure, consisting of more than one form of hornblende, augite, decomposition products replacing felspar, and grains of black iron peroxide. These secondary microlithic products have so obliterated the structure of the felspar that it is difficult to come to any conclusion about the species; one or two crystals, however, seem to retain faint indications of plagioclase twinning. Of the hornblende, some is the dark-brown strongly dichroic variety, some a pale-green kind, and perhaps a little of an acicular type, a sort of actinolite. The green hornblende is probably a secondary formation after augite, and so may be called uralite. Some of it is also very closely associated with the brown variety, as though formed from it, or as if both were alteration products. There is also a secondary product of a serpentinous nature. A fair amount of unaltered augite is still present. The magnetite (?) grains are not usually associated with the hornblende or augite. There is also very probably some siderite. It is difficult to affix a name to the rock, perhaps hornblendic or uralitic diabase would be the best.

[Cl. 17.] *Hornblende diabase*, loose block under Gyrn Goch; a coarsely crystalline rock speckled brown and white, with lustrous cleavage planes of the bisilicates; there is considerable effervescence with acid.

Microscope.—A general similarity to the last, except that the hornblende is rather more platy or bladed, possibly also a little delessite or some kindred mineral. One or two grains of a yellowish mineral of rather granular structure (? sphene).

[Cl. 24.] *Hornblende diabase*, below the turnpike *in situ*, not far from the preceding, under Gyrn Goch near Clynnog. The hand-specimen is rather coarsely crystalline; a dark-green ground with bronze-coloured bisilicates. Golden-coloured mica fairly abundant. Active effervescence with acid.

Microscope.—The predominant mineral in the slide is hornblende. Of this, there appear to be three varieties: (1) Seemingly an original constituent with characteristic cleavage, and strong dichroism, giving shades of brown; (2) perhaps an altered form of this, less strongly dichroic, giving shades of green; (3) certainly of secondary formation, a kind of tremolite, almost colourless. There is, however, some augite, also an original constituent. There appears to have been a fair amount of felspar, but it is now replaced by various secondary constituents, such as earthy matter, zeolites, calcites, etc. Opacite, perhaps magnetite, a little apatite, calcite, serpentinous looking, and other decomposition products are present.

[Cl. 1.] *Pentrebach,* a hill E. of Llanaelhairn near Clynnog; a purplish-grey, fine-grained felsitic rock with small brownish-yellow felspars; slight effervescence with acid.

Microscope.—The ground-mass is rather decomposed, but shows in places the remains of a wavy branching fluidal structure. With crossed Nicols we see it to be cryptocrystalline. There are some grains of quartz and a good many crystals of rather decomposed felspar; plagioclase seemingly predominating. There is a fair amount of iron peroxide, probably hematite, in most cases associated with and replacing parts of felspar crystals. We note also a little epidote and traces of a pyroxenic mineral. There is a curious case of one quartz crystal inclosing another. The rock was probably once a lava, akin to rhyolite. T. G. B.

IV.—An Account of Volcanic Eruptions and Earthquakes which have taken place in Iceland within Historical Times.

By Thorvaldr Thoroddsen.

Few spots on the face of the globe of the extent of Iceland could be mentioned where, within the same space, an equal number of volcanos could be found. In that island, too, many volcanic eruptions have occurred, which have been, perhaps, of greater magnitude than any others recorded as having taken place anywhere else on the earth. And yet the volcanos of Iceland are but imperfectly known, and, with the exception of two or three, not one of the rest has ever been scientifically examined. Hence the fact, that geological manuals so frequently contain most erroneous statements concerning this subject. A general uncertainty prevails as to how many volcanos have actually been in a state of eruption within historical times; dates are dealt with in a confused manner; and frequently mountains come to figure as volcanos which have never shown any signs of eruptive activity.

Yet, by critically sifting Icelandic records on this subject existing in print and MSS., a pretty exact and accurate list may be drawn up of volcanic eruptions and earthquakes, which, within historical times, have occurred in Iceland. And of these phenomena I beg to offer a short review, being an abstract of a larger work on the subject, which I have in preparation, wherein each eruption and each earthquake will be carefully and minutely described, and the authorities critically tested on which the evidence rests.

The following is a list of volcanos which within historical times have been in a state of volcanic activity, and of earthquakes which have occurred within the same period.

Eldborg (Fire-burgh, 64° 47′ north lat. 34° 54′ west long. mer. Copenhagen[1]) in the district of *Myrasysla* (Fen-bailiwick, Bailiwick of the Fen country), the first crater mentioned in history in a state of eruption in Iceland. It is about 200 feet high, situated in the midst of a plain, and surrounded on all sides by lava.

Hekla (The Mantle; the name doubtless derived from its shape at a distance reminding the beholder of a bemantled corpulent woman, 63° 59′ n.l. 32° 19′ w.lo.), the most famous of all Icelandic volcanos; seven geographical miles inland from the nearest point of the coast. It is 4956 feet high, piled up of blocks of lava, masses of pumice-stone and ashes. Parallel with this somewhat strongly longitudinally shaped mountain, there run from S.W. to N.E. ridges of other mountains, composed of palagonite breccia and tufa. All around Hekla vast stretches of lava, produced by countless successive eruptions, extend in every direction. On the mountain itself, as well as in its immediate neighbourhood, a great number of craters may be observed. This is the most widely and most accurately known of all Icelandic volcanos.

Rauðu-kambar (Red Combes, 64° 12′ n.l. 32° 25′ n.lo.), a ridge of mountains following the direction of the line of Hekla, has, so far as is historically known, erupted only once, A.D. 1343. The land all about this range is covered with sand and ashes.

Reykjanes (Reek [= Smoke or Steam]-ness), volcanic throughout; it consists of alternate layers of tufa and trap, rising up to plateaux of 400 feet high, on the surface of which there is a long series of volcanos rising even to the height of 2000 feet, but now mostly extinct. This series of volcanic peaks takes the same direction as the line of Hekla. A number of volcanic springs and earthquake chasms are to be found all about this neighbourhood.

Þurrár-hraun (Dry-river lava, 64° n.l. 33° 55′ w.lo.), the outcome of an eruption which happened A.D. 1000, on the upland plateau called *Hellis-heiði* (=Hollow-heath, *i.e.* the cavernous heath; even to-day it sounds cavernous in certain places, as the traveller rides over it); it took an easterly current over the plateau, and issued finally through a pass on the eastern, somewhat precipitous, side of it into the lowland plains below.

Trölla-dyngja (Trolls' bower, 63° 56′ n.l. 34° 14′ w.lo.), one of the many peaks that stud the volcanic ridge of *Reykjanes*, is situated to the N.W. of the sulphur mines of *Krisuvík*. Six eruptions from

[1] The meridian of Copenhagen is used because it is the meridian employed in Gunnlögsen's Map of Iceland, the largest, fullest, and most correct existing.

this peak are on record, which have been erroneously transferred by various writers to a volcano of a similar name in the north of Iceland.

Eld-eyjar (Fire-isles), a series of volcanic rocks situate in the sea 1½ geographical miles off the S.W. point of *Reykjanes;* about the neighbourhood of these rocks, and sometimes as far out at sea as eight miles from the land, volcanic eruptions are known to have taken place.

In the extensive complex of glaciers, comprehensively denominated as Mýrdals-jökull (Moor [= Fen] -dale - jökul [= icle, *i.e.* ice = glacier]), S.E. of Hekla, there are two volcanos: Eyja-fjalla-jökull (Isle-fell-glacier, deriving its name undoubtedly from the islands, called Vest-manna-eyjar, *i.e.*, the West-mens' = [the Irelanders'] Islands, so called from the fact of their having been occupied, when the country was discovered, by Irish hermits,—a group of islands outside the coast from which the Eyjafjöll (Isle-fells) rise —63° 37′ n.l. 32° 16′ w.lo.), 5432 feet high; and Katla (Kettle, Caldron), which is not shaped like a volcano, but is merely a volcanic chasm, generally covered with ice. It is situate in the eastern part of Mýrdals-jökull (63° 37′ n. l. 31° 35′ w. lo.); but has never been explored. Eyjafjalla-jökull has twice been in a state of eruption, but Katla thirteen times. It should be observed that eruptions from these last-named eruptive sources, as well as indeed from some other mountains in Iceland, are accompanied by enormous floods of water, bringing down huge blocks of ice, which covered the surface of the crater before the eruption took place. The lowlands below such volcanos represent extensive and entirely barren wastes, which have been produced by the masses of pulverized lava and the prodigious glacier-slips which are brought down by the inundations caused by the eruptions. To the N.E. of Mýrdals-jökull are many craters to be found in the so-called Varmár-dalr (Warm-river-dale), in the neighbourhood of *Skaptá* (Shaft-river?), as well as in the vicinity of Hverfisfljót (Wharf-fleet), which in 1783 emitted enormous masses of lava.

Along the borders of *Vatna-jökull* (Waters' glacier), a glacial upheaval of no less than 150 square geographical miles in extent, volcanos are found in great number. On its southern boundary, the easternmost is Öræfa-jökull (Desert-glacier, 64° n.l. 29° 21′ w.lo.), the highest mountain in Iceland, rising to 6241 feet. This mountain has been in a state of eruption three or four times. Some distance to the westward, on the borders of Skeiðarár-jökull, various craters are found, as also in the neighbourhood of *Grímsvötn* (Grim's waters), and *Síðujökull* (Side-glacier), where many and most violent eruptions have taken place. But these tracts constitute as yet a *terra incognita.* On the northern border of Vatnajökull we find *Kverk-fjöll* (Kverk = throat, 29° 20′ w.lo.), almost entirely unknown, although eruptions have taken place in that neighbourhood three or four times. To the north of Vatna-jökull is the so-called Odáðahraun (Misdeed-lava), 60 square geographical miles in extent, where there are a good many almost entirely unknown volcanos. The only volcanic spot in these tracts which has been examined is the Dyngju-fjöll, situated in the centre of this desert of lava. It is a complex of mountain-peaks rising up to even 4500 feet high, inclosing the circularly formed valley called *Askja* (=the Basket, measuring one square geographical mile in extent, and situate 3900—3500 feet above the level of the sea), where a terrific eruption took place in 1875. In the S.E. corner of this valley is found a 'dip' in the earth 750 feet "down," within which there is a round hot lake, 4000 feet in diameter. Around the edge of this dip many large craters are situated. The bottom of this valley is covered with lava, which represents an eastward incline of 1° 26′ towards the mouth of the valley, which opens into the surrounding lava-waste of Odáðahraun.

About the lava-plateau, called Mývatns-öræfi (Mosquito-water-wastes), which stretches northward from the surroundings of Dyngju-fjöll, great eruptions occurred during the same year in which that of Dyngju-fjöll was going on (in 1875); and in a certain hollow in this tract called Sveina-gjá (Swains' rift) many new craters were formed rising to the height of 70 to 108 feet. These craters range on a line in the direction from S. to N.

All round Mývatn (Mosquito-water) there is an enormous number of craters, lava-formations, sulphur-mines and hot springs. This neighbourhood was visited by very severe eruptions during the period from 1724 to 1730. The chief volcanos are Krafla and Leirhnúkr (Clay-peak), which form ridges of palagonite running from S. to N. During the period of volcanic disturbance just mentioned similar activity was also going on in *Hrossa-dalr* (Horse-dale), *Bjarnar-flag* and about the site of the so-called *Reykjahlíðar-sel.*

I have now enumerated all the volcanos which are known to have been in a state of volcanic activity in historical times in Iceland. But besides these there is to be found in the country an enormous number of extinct volcanos; and some tracts of the island, as, for instance, the whole neighbourhood of Mývatn, are so thickly studded with these reminders of prehistoric convulsions as to give the beholder an impression of having before him a map of the Moon.

By observing the geological construction of Iceland, it will be found, that there are still two volcanic lines in active condition; lines, which manifest themselves not only by the direction which the craters generally represent, or by the rifts and chasms of the volcanos, but stand in close relation to the formation of the country generally. The one line goes from S.W. to N.E. represented by the Reykjanes peaks, Hekla, and several other volcanos of Southern Iceland. The other line runs from S. to N., on which, in straight rows, are standing the craters of the volcanos round Vatnajökul and Mývatn. These lines, we also observe, are represented by the mountain-ranges, valleys, firths, and rivers of the country. Hot springs and mines (sulphur), we observe, occupy the same lines, which are also followed by the earthquakes. Ranges of peaks, of trachyte, which have shot up through older formations, follow this same law, and submarine reefs go in the same drift.

The volcanos which are still active in Iceland seem to be mostly associated with palagonite-tuffa.

At the following dates eruptions and earthquakes have taken place in Iceland in historical times:

A.D.

c. 900 Eldborg erupted about the year 900; there are no means of more accurately defining the precise year of this eruption.

894 *First* eruption from *Katla*. The land between *Eyjará* (Island-river) and *Hólmsá* (Holme's-river) was laid waste, and a whole district, *Dynskógahverfi* (Wharf of the rustling woods) was never afterwards inhabited. Ruins of homesteads destroyed this year were found in the beginning of the 17th century.

934 *Second* eruption from *Katla*. Then, as the tale goes, the *Jökulsá* on *Sólheimasandr* (Sun-home-sand) came into existence.

1000 Eruption from *Hellisheiði*, when *Þurrárhraun* was formed, which flowed down into the close vicinity of the farm *Hjalli* in the district of Olves.

1013 Earthquakes about the country; 11 persons perished.

1114 *First* eruption from *Hekla*; the ensuing winter was called "sand-fall-winter."

1151 *First* eruption from *Trölladyngjur*; houses fell in, in many places, from earthquakes, and loss of life took place.

1157 *Second* eruption from *Hekla*, 19th Jan., accompanied by violent earthquakes.

1164 Earthquake in *Grimsnes*, loss of 19 lives.

1182 Earthquake, loss of 11 lives.

1188 *Second* eruption from *Trölladyngjur*.

1206 *Third* eruption from *Hekla*, 4th December, which continued far into the spring.

1211 *First* eruption off *Reykjanes* in the tract of the *Eldeyjur*. Great earthquakes about the South-country, loss of 18 lives.

1222 *Fourth* eruption from *Hekla*.

1225 The winter of this year is called "Sand-winter," but the locality of the eruption is unknown.

1226 *Second* eruption off *Reykjanes*.

1231 *Third* ditto.

1238 *Fourth* ditto.

1240 *Fifth* ditto. Excessively violent earthquakes throughout the South-country. This year, it is reported, one half of *Reykjanes* was laid waste.

1245 *Third* eruption from *Katla*. The glacier-slip swept over *Sólheimasand*. Ashes covered the earth to the extent of ¼ of an ell.

1260 Great earthquakes about the North country.

1262 *Fourth* eruption from *Katla*, swept over *Sólheimasand*.

1294 *Fifth* eruption from *Hekla*. Violent earthquakes; huge chasms opened in the earth; wells and fountains became white as milk for three days; *Rangá* (Wrong-river) changed its course; rivers were covered with pumice. Some new hot springs came into existence, others vanished.

1300 *Sixth* eruption from *Hekla*, July 13th, one of the most violent on record. The ashes were borne by a S.W. wind over the North-country and covered a large portion of it. Great earthquakes. Famine and great loss of life followed.

1308 Earthquakes throughout the South-country. Eighteen homesteads reduced to ruins.

1311 *Fifth* eruption from *Katla*, Jan. 25th, preceded by violent earthquakes; 51 homes fell in. A whole district near *Katla*, called *Lágeyjarhverfi* (Low-isle-wharf), was laid completely waste.

1332 Eruption somewhere about the district called *Síða* (the Side); exact locality unknown.

1339 Earthquake in the South-country; many homesteads fell in; a hot spring, forty fathoms in circumference, was formed in *Henglafjöll* (= the overtopling-fells).

1340 *Third* eruption from *Trölladyngjur*.

1341 *Seventh* eruption from *Hekla*; the ashes fell all about the South-country, many homes were destroyed by earthquakes this year.

,, Eruption from *Oræfajökull*.

1343 Eruption from *Rauðukambar*; eleven homesteads completely destroyed.

1349 or 1362 (the annals are most conflicting as to the date). A succession of most fearfully violent eruptions from *Oræfajökull* took place. When the ice-cover of the mountain was thrown off, and came down with the rush of the waters to the sea, it carried so much with it of stones, sand and debris, that, where formerly the sea measured a depth of 30 fathoms, there was a dry beach after the eruption. Five fertile districts were laid totally and irretrievably waste; forty homesteads and two churches were swept away in the flood.

1360 *Fourth* eruption from *Trölladyngjur.*

1370 Earthquakes; eleven homesteads fell in in *Olves.*

$13\frac{89}{90}$ *Eighth* eruption from *Hekla.*

,, *Fifth* eruption from *Trölladyngjur.*

,, Eruption from *Síðujökull.*

1391 Earthquakes throughout *Grimsnes*, *Flói* (the Bog) and *Olves*; fourteen homesteads damaged; loss of life. The earthquakes went northward as far as *Holtavörðuheiði* (Heath of the beacons on the hill-rises).

1416 *Sixth* eruption from *Katla.*

1422 *Sixth* eruption off *Reykjanes.*

1436 *Ninth* eruption from *Hekla*, eighteen homesteads destroyed.

1477 Eruption in the unknown Wildernesses, great fall of ashes in the North-country, followed by famine and loss of life.

1510 *Tenth* eruption from *Hekla*, July 25th; great fall of ashes, huge blocks of lava were cast at a long distance out of the mountain; many people were killed by these falling.

,, *Sixth* eruption from *Trölladyngjur.*

1516 Earthquakes in *Olves* in the beginning of June, many homesteads tumbled down.

1552 Earthquakes on the 2nd of February.

1554 *Eleventh* eruption from *Hekla* towards the end of May; took its rise from the mountain range which goes in a N.E. direction from *Hekla.* Earthquakes so frequent and violent that people were obliged to live in tents the greater part of the summer.

1578 *Twelfth* eruption from *Hekla*, November 15th.

1580 *Seventh* eruption from *Katla*; several farmsteads destroyed.

1581 Great earthquake through *Rangarvellir*, May 30th.

1583 *Seventh* eruption off *Reykjanes.*

1584 Earthquakes.

1597 *Thirteenth* eruption from *Hekla*, excessively violent, began January 3; the loud reports were heard for twelve successive days even in the northernmost parts of the country; eighteen columns of fire were seen rising from the mountain. Left off in March, but the mountain continued to smoke even up to July; the ashes covered about one-half of the country, from *Borgarfjörðr* (Burg-firth) in the West to the district called *Lón* (Wash) in the east, and North as far as *Bárðardal* (Bárd's-dale). This same spring there occurred earthquakes about *Olves*, through which many farmsteads fell in and a large hot spring to the south of the farm-house of *Reykir* disappeared, and another opened elsewhere.

1598 Eruption about *Grimsvötn* and from *Oræfajökull.*

1612 *First* eruption from *Eyjafjallajökull.*

1613 Great earthquakes in the South-country, many homesteads tumbled down.

1618 Earthquakes frequent in the autumn about the district of *Thingeyjarsy'sla* in the North.

1619 *Fourteenth* eruption from *Hekla.* Great fall of ashes in the North.

1624 Earthquake in *Flói* in the month of November.

1625 *Eighth* eruption from *Katla*, September 2-4. Great fall of ashes; some ashes fell in *Bergen* in Norway.

1633 Earthquakes in *Olves.*

1636 *Fifteenth* eruption from *Hekla*; began May 8; thirteen craters opened; ashes fell mostly in the South-East of Iceland.

1638 Eruption in the wildernesses in the East-country, February 27th.

1643 Earthquakes on Christmas Eve.

1657 Earthquakes, many homesteads fell in in *Fljótshlíð* (Fleet-leeth).

1660 *Ninth* eruption from *Katla*, began November 3rd; such was the quantity of sand, stones and debris borne down with the flood from the mountain, that a dry beach was formed where formerly people fished in a depth of 20 fathoms; the coast was pushed 1000 fathoms out into the sea; five or six farmsteads were destroyed.

1661 Earthquakes during the summer.
1681 Eruption from *Skeiðarárjökull.*
1685 Eruption in the neighbourhood of *Grimsvötn.*
1693 *Sixteenth* eruption from *Hekla*, February 13th, left off in August. Four craters were active. The ashes fell all over the country, and were carried even over to Norway. The pumice masses drifted all the way to *Faro.*
1706 Severe earthquakes in *Olves* and *Flói*, April 1st and 20th. Twenty-four manors fell in and many cottages.
1716 Eruption in the neighbourhood of *Grimsvötn.*
1717 Eruption from *Kverkfjöll*, September 17th. *Thingeyjarsy'sla* suffered great damage from the ashes, which also fell in *Eyjafjarðarsy'sla* and *Múlasy'sla.*
1721 *Tenth* eruption from *Katla*; began May 11th with excessive floods and glacier-slips; the ice-blocks grounded in depths of from 70-80 fathoms 3 (Danish) miles out at sea. A grass-grown neck of land was swept away, and in its stead was left a polished slab of rock 6750 square fathoms in extent. The ashes were borne westward, and fell so thick the first day that at homesteads 25 geographical miles distant from the crater the light was obscured to such an extent as to make reading of print impossible.
1724 Eruption from *Krafla*, May 17th, great masses of ashes and pumice issued from a crater on its western side called *Víti* (Hell); on the eastern shores of *My'vatn* the layer of the ashes was 1½ ell thick.
1725 Eruption from *Leirhnúkr*, January 11th, accompanied by severe earthquakes. Eruption from *Bjarnarflag*, April 19th; violent earthquakes on the 8th of September. Eruption in *Skeiðarárjökull.*
1727 Eruption from *Oræfajökull*, August 3rd, great floods from the glacier, which destroyed homesteads and killed cattle; the eruption abated May 25th, 1728. At the same time great disturbances were observed in *Skeiðarárjökull*, and on August 21st an eruption took place from *Leirhnúkr.*
1728 Eruption from *Leirhnúkr*, April 18th, preceded by severe earthquakes, the lava flowed almost close down to the parsonage of *Reykjahlíð*; the same day an erupting crater opened in *Hrossadalr*, while another eruption also took place in *Bjarnarflag.* April 20th great masses of lava welled out in the neighbourhood of *Reykjahlíðarsel*, from a crater situate on the eastern slope of *Dalfjall.* December 18th *Leirhnúkr* was in eruption and this same year volcanic action was going on in the lava wastes round *Hekla.*
1729 Eruption from *Leirhnúkr*, January 30th, which continued through the year; huge masses of lava flowed from the volcano in the direction of *Reykjahlíð*, which stead was destroyed, together with three others. Only the church of *Reykjahlíð* was left standing.
1734 Earthquake in the *Flói.*
1749 Earthquakes throughout *Olves* and *Borgarfjörd*; the hot spring of *Skrifla* diminished and grew colder than before.
1752 Earthquake in *Arnessy'sla*; 12 farmsteads were damaged and one church fell in.
1753 Eruption in the neighbourhood of *Síðujökull*, accompanied by great glacier floods; the river *Djúpá* (Deep river) rose by 200 feet, devastating the surrounding lands; the district of *Skaptártunga* was completely covered with ashes.
1754 Eruption in the lava fields to the westward of *Hekla* which lasted for three days.
1755 Severe earthquakes for six days, September 10-15, in the North-country, especially about *Húsavík*, during which twenty-one homesteads were destroyed. October 17th a formidable eruption began from *Katla*—the *eleventh*—which went on till August, 1756. Glacier-floods and ashes created vast devastation. The land all about *Skaptafellssy'sla* was covered by a layer of ashes from ¼ to 1 ell in thickness, and fifty homesteads were destroyed.
1766 *Seventeenth* eruption from *Hekla*, accompanied by severe earthquakes to the S.W. of it all the way out to *Reykjanes.*
1774 Eruption in the wildernesses about *Skeiðarárjökull.*
1783 *Eighth* eruption off *Reykjanes.* Great eruptions about *Varmárdalr* along *Skaptá* began in June, and after some intermission were repeated towards the end of July about the sources of *Hverfisfljót.* These eruptions were of a magnitude unparallelled on the earth in historic times. The lava which they produced exceeds, on the authority of Sir Charles Lyell, in cubic contents the mass of Mont Blanc. These eruptions were followed by famine and great loss of life—

in fact they proved fatal to 9,000 human beings, 21,000 cattle, 233,000 sheep and 36,000 horses. These eruptions are erroneously stated to have taken place in *Skaptárjökull*, where an eruption has never yet occurred.

1784 Earthquake in *Arnessy'sla*, August 14-16, the severest in historical times, destroying 69 homesteads. Eruption from *Skeiðarárjökull*.

1789 Earthquakes in the South-country, especially in the neighbourhood of *Thingvallavatn* (Thing-wall-water [lake]).

1808 Earthquakes in many places about Iceland.

1810 Earthquake, October 24th, to the east of *Hekla*.

1815 Earthquake, during the month of June, in the North-country.

1818 Slight earthquakes in the South-country.

1821 *Second* eruption from *Eyjafjallajökull*.

1823 *Twelfth* eruption from *Katla*, commencing June 26th, continued for 28 successive days. Same year eruption in the neighbourhood of *Skaptá* by *Varmardalr*.

1826 Earthquake in the North-country.

1829 Earthquake in the South, February 22nd; seven homesteads fell in.

1830 *Ninth* eruption off *Reykjanes*.

1838 Earthquakes from 12th to 19th June, both in the North and in the South.

1839 Earthquake in the neighbourhood of *Reykjavík*, July 28th.

1845 *Eighteenth* eruption from *Hekla*, commenced on the 2nd of September and continued for seven months. The ashes were carried over to *Shetland* and the column of smoke rising out of the mountain reached a height of 14,000 feet. The lava which this eruption produced contained a mass of 14,400 millions cubic feet.

1855 Slight earthquakes in the North.

1860 *Thirteenth* eruption from *Katla*, May 8-27; earthquakes in the autumn.

1862 Eruptive activity in the wildernesses about *Vatnajökull*.

1863 Earthquakes about *Reykjavík*, April 20-21.

1864 Earthquake February 16th.

1867 Eruption from *Kverkfjöll*, August 29—September 5.

1868 Earthquake in the South, November 1-3.

1872 Violent earthquakes at *Húsavík* in *Thingeyjarsy'sla*, April 17th, the disturbances abated not till the middle of May, many homes came down.

1873 Eruption in *Kverkfjöll*, January 8-13; considerable fall of ashes in the East and the South.

1875 Eruption from *Dyngjufjöll*, January 3rd; February 18th, an eruption commenced in *Sveinagjá* on *My'vatnsöræfi*, which continued to the end of the year. March 29th, a formidable explosion took place in *Dyngjufjöll*, which covered the whole of Eastern Iceland with pumice and ashes; the latter being carried all the way to Norway and even Sweden.

1878 Eruption to the N.E. of *Hekla*, accompanied by somewhat severe shocks of earthquake, commenced February 27th, terminated in May.

1879 *Tenth* eruption off *Reykjanes*, May 30 and 31.

I have enumerated the eruptions about which full certainty is obtainable. Lists of eruptions and earthquakes in Iceland have been drawn up by various writers, as, for instance, *Haldór Jakobsson* (1757), *G. Garlieb* (1819), *Eugen Robert* (1840), and *F. Zirkel* (1862); but into these accounts various mis-statements have crept, owing, partly, to the records being treated with lax criticism, and, partly, to insufficient familiarity with the topography of the country. The more recent writers have mostly followed *Haldór Jakobsson* and *Garlieb*, without studying the original records, and the errors which the writings of these authors contain are mostly traceable to their sources.

Of the volcanos, and volcanic localities, which the authorities referred to state to have been in activity at various times, the following may safely be struck out: *Asmundarnúpr*, *Thóreyjarnúpr*,

ERUPTIONS IN ICELAND.

(The Volcanos are arranged according to the site they occupy in the country.)

Volcano	Eruptions
Eldborg.	c. 900
Off Reykjanes about Eldeyjar.	1211, 1226, 1231, 1238, 1240, 1422, 1583, 1783, 1830, 1879
Trölladyngjur.	1151, 1188, 1340, 1360, 1389
Þurrárhraun.	1000
Hekla.	1114, 1157, 1206, 1222, 1294, 1300, 1341, 1389, 1436, 1510, 1554*, 1578, 1597, 1619, 1636, 1693, 1728*, 1754*, 1766, 1845, 1878*
Rauðukambar.	1343
Eyjafjalla-jökull.	1612, 1821
Katla.	894, 934, 1245, 1262, 1311, 1416, 1580, 1625, 1660, 1721, 1755, 1823, 1860
Varmárdalr.	1783, 1823
Síðujökull.	1389, 1753
Grímsvötn.	1598, 1685, 1716
Skeiðarárjökull.	1681, 1725, 1727, 1774, 1784
Öræfajökull.	1341, 1362, 1598, 1727
Eruptions in the Wildernesses.+	1225 (?), 1332 (Síða), 1477, 1638, 1862
Kverkfjöll.	1717, 1867, 1873
Dyngjufjöll.	1875
Sveinagjá.	1875
Krafla.	1724
Leirhnúkr.	1725, 1727, 1728, 1729
Hrossadalr.	1728
Bjarnarflag.	1725, 1728
Dalfjall.	1728

* These eruptions did not occur in Hekla itself, but in the lava-wastes, and mountain ranges in the neighbourhood of it.

+ Eruptions which have occurred in the wildernesses are placed here because most o them have in all probability taken place in the vicinity of *Vatnajökull*.

Hofsjökull, Baldjökull, þestareykir, Fremri-Námar, Hverfjall, Sandfellsjökull, Her'Subrei'S, Skaptárjökull, Sólheimajökull, Brei'Samerkrjökull, þórsmörk, Torfajökull, Mosfell, Helgafell.

The following eruptions are referred to wrong dates: *Hekla*, 1004, 1029, 1113, 1374, 1583, 1625, 1772; *Katla*, 1717, 1727; *Trölladyngjur*, 1475; *Her'Subrei'S*, 1341, 1510; *Sí'Sujökull*, 1728; *Oræfajökull*, 1720; an eruption in *Brei'Sifjördr*, by *Snæfellsnes*, 1219, and 1345; *Hverfjall*, 1748–1752; *þingvallahraun*, 1587; *þórsmörk*, 1300–1350.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science, Fiftieth Meeting, Swansea, August 26th, 1880.

Titles of Papers Read in Section C. (Geology).

Opening Address by H. C. Sorby, LL.D., F.R.S., President.—"On the Comparative Structure of Artificial Slags and Eruptive Rocks." (See p. 468.)

C. E. De Rance, F.G.S.—Report on the Circulation of the Underground Waters in the Permian, New Red Sandstone, and Jurassic Formations of England; and on the quality and character of the water supplied to towns and districts from those formations.

A. R. Hunt, F.G.S.—Notes on the Submarine Geology of the English Channel off the Coast of South Devon.

Prof. W. Boyd-Dawkins, M.A., F.R.S.—On the Action of Carbonic Acid on Limestone.

F. C. J. Spurrell, F.G.S.—On the Site of a Palæolithic Implement Manufactory, at Crayford, Kent.

Prof. J. P. O'Reilly.—On the Relations to be Established between Coast-line-Directions represented by Great Circles on the Globe, and the localities marked by Earthquakes in Europe.

G. H. Kinahan, M.R.I.A., Pres. Geol. Soc. Ireland.—On the Hiatus said to have been found in the rocks of West Cork.

W. H. Dalton, F.G.S.—Note on the Range of the Lower Tertiaries of East Suffolk.

W. Pengelly, F.R.S., F.G.S.—Sixteenth Report of the Committee appointed to explore Kent's Cavern, Devonshire.

Prof. A. Leith Adams, F.R.S.—Report on the Exploration of Caves in the South of Ireland.

Prof. H. G. Seeley, F.R.S.—Report on the Viviparous Nature of the *Ichthyosauria.*

G. R. Vine.—Report on the Carboniferous Polyzoa.

W. Whitaker, B.A. Lond., F.G.S.—Report on the "Geological Record."

Prof. W. J. Sollas, M.A., F.G.S.—On the Island of Torghatten, Norway; and on the Influence of Joints on Denudation.

Prof. W. J. Sollas, M.A., F.G.S.—On the Contortion of a Quartz-vein in Mica-schist from Bodö, Norway.

W. T. Blanford, F.R.S., F.G.S.—On the Geological Age and Relations of the Sewalik and Pikermi Vertebrate and Invertebrate Faunas.

E. Wethered, F.G.S.—On the Sandstones and Grits of the Lower and Middle Series of the British Coal-field.

Dr. H. Hicks, F.G.S.—On some Pre-Cambrian Rocks in the Harlech Mountains.

Prof. J. Prestwich, M.A., F.R.S.—On a Raised Beach with Diluvial Drift in Rhos Sili Bay, Gower.

Prof. J. Prestwich, M.A., F.G.S.—On the Geological Evidence of the Submergence of the South-west of Europe during the early Human Period.

Charles Moore, F.G.S.—Proofs of the Organic Nature of *Eozoon Canadense.*

J. H. Collins, F.G.S.—On the Fault-systems of Central and West Cornwall.

Dr. G. M. Dawson, F.G.S.—Sketch of the Geology of British Columbia.

Dr. J. S. Phené, F.G.S.—On the Geology of the Balearic Islands.

Prof. W. J. Sollas, M.A., F.G.S.—On the Action of a Lichen on Limestone.

Prof. W. J. Sollas, M.A., F.G.S.—On a Striated Stone from the Trias, of Portishead.

Prof. W. J. Sollas, M.A., F.G.S.—On Sponge Spicules from the Chalk of Trimmingham, Norfolk.

W. H. Baily, F.G.S.—Report on the Tertiary Flora of the Basalts of the North of Ireland.

Rev. H. W. Crosskey, F.G.S.—Report on the Erratic Blocks of England and Wales.

W. Whitaker, B.A. Lond., F.G.S.—On the Geological Literature of Wales.

Lieut.-Col. Godwin-Austen, F.R.S.—On the Post-Tertiary and Glacial Deposits of Kashmir.

R. Bruce-Foote, F.G.S.—Notes on the Occurrence of Stone Implements in the Coast Laterite, South of Madras, and in High Level Gravel and other formations in the South Mahratta Country.

C. E. De Rance, F.G.S.—On the Pre-Glacial Contours and Post-Glacial Denudation of the North-west of England.

II.—British Association for the Advancement of Science, Swansea, August 26, 1880. Address to the Geological Section by Henry Clifton Sorby, LL.D., F.R.S., F.G.S., President of the Section.

IN selecting a subject for an address to be given in accordance with the custom of my predecessors, I was anxious that it should be, in some way or other, connected with the locality in which we have met. If I had been adequately acquainted with the district, I should have thought it incumbent on me to give such an outline of the general geology of the surrounding country as would have been useful to those attending this meeting. I am, however, practically a stranger to South Wales, and must therefore leave that task to others. On reflecting on the various subjects to which I might have called your attention, it appeared to me that I could select one which would be eminently appropriate in a town and district where iron and copper are smelted on so large a scale, and, as I think, also equally appropriate from a geological point of view. This subject is the comparative structure of artificial slags and erupted rocks. In making this choice I was also influenced by the fact that in my two anniversary addresses as President of the Geological Society I have recently treated on the structure and origin of modern and ancient stratified rocks, and I felt that, if in the present address I were to treat on certain peculiarities in the structure of igneous rocks, I should have described the leading conclusions to which I have been led by studying the microscopical structure of nearly all classes of rocks. It would, however, be impossible in the time now at disposal to treat on all the various branches of the subject. Much might be said on both the purely chemical and purely mineralogical aspects of the question; but though these must not be ignored, I propose to draw your attention mainly to another special and remarkable class of facts, which, so far as I am aware, have attracted little or no attention, and yet, as I think, would be very instructive if we could fully understand their meaning. Here, however, as in so many cases, the observed facts are clear enough, but their full significance somewhat obscure, owing to the want of adequate experimental data or sufficient knowledge of general physical laws.

A considerable amount of attention has already been paid to the mineral constitution of slags, and to such peculiarities of structure as can be learned independently of thin microscopical sections. A very complete and instructive work, specially devoted to the subject, was published by Von Leonhard about twenty-two years ago, just at the time when the microscope was first efficiently applied to the study of rocks. Since then Vogelsang and others have described the microscopical structure of some slags in connexion with their studies of obsidian and other allied volcanic rocks. At the date of the publication of Von Leonhard's work the questions in discussion differed materially from those which should now claim attention. There was still more or less dispute respecting the nature and origin of certain rocks which have now been proved to be truly volcanic by most unequivocal evidence; and I am not at all surprised at this, since, as I shall show, there is such a very great difference in their characteristic structure and that of the artificial products of igneous fusion, that, but for the small portions of glass inclosed in the constituent crystals, described by me many years ago under the name of 'glass-cavities,' there would often be no positive proof of their igneous origin. There was also considerable doubt as to the manner in which certain minerals in volcanic rocks had been generated. The observed facts were sufficient to prove conclusively that some had been formed by sublimation, others by igneous fusion, and others deposited from more or less highly heated water; but it was difficult or impossible to decide whether in particular cases certain minerals had been formed exclusively by one or other process, or sometimes by one and sometimes by the other, or by the combined action of water and a very high temperature. I must confess that, even now that so much may be learned by studying with high magnifying powers the internal structure of crystals, I should hesitate very much in deciding what were the exact conditions under which certain minerals have been formed. This hesitation is probably as much due to inadequate examination and to the want of a complete study of typical specimens, both in the field and by means of the microscope, as to the unavoidable difficulties of the subject. Such doubt, however, applies more to the origin of minerals occurring in cavities than to those constituting a part of true rock-masses, to which latter I shall almost exclusively refer on the present occasion. In the formation of these it appears to me that sublimation has occurred to a very limited extent. In many cases true igneous fusion has played such a leading part that the rocks may be fairly called *igneous*, but in other cases, water, in some form or other, has, I think, had so much influence that we should hesitate to call them *igneous*, and the term *erupted* would be open to far less objection, since it would adequately express the manner of their occurrence, and not commit us to anything open to serious doubt.

In studying erupted rocks of different characters, we see that at one extreme they are as truly igneous as any furnace-product, and, at the other extreme, hardly, if at all, distinguishable from certain deposits met with in mineral veins, which furnish abundant evidence of the preponderating, if not exclusive, influence of water, and have very little or nothing in common with products certainly known to have been formed by the action of heat, and of heat alone. Between these extremes there is every connecting link, and in certain cases it is almost, if not quite impossible to say whether the characteristic structure is due more to the action of heat than of water. The great question is, whether the presence of a small quantity of water in the liquid or gaseous state is the true cause of very well-marked differences in structure;

or whether greater pressure, and the necessarily slower rate of cooling, were not the more active causes, and the presence of water in one state or another was merely the result of the same cause. This is a question which ought to be solved by experiment; but I fear it would be almost impossible to perform the necessary operations in a satisfactory manner.

What I now propose to do is to describe a particular class of facts which have lately attracted my attention, and to show that the crystalline minerals in products known to have been formed by the action of heat alone, have a certain very well-marked and characteristic structure, which is gradually modified as we pass through modern and more ancient volcanic to plutonic rocks, in such a manner as to show at once that they are intimately related, and yet differ in such characteristic particulars that I think other agencies than mere heat must have had great influence in producing the final result.

In dealing with this subject, I propose, in the first place, to describe the characteristic structure of products formed artificially under perfectly well-known conditions, and then to pass gradually to that of rocks whose origin must be inferred, and cannot be said to have been completely proved.

Crystalline Blowpipe Beads.—Some years ago I devoted a considerable amount of time to the preparation and study of crystalline blowpipe beads, my aim being to discover simple and satisfactory means for identifying small quantities of different earths and metallic oxides, when mixed with others; and I never supposed that such small objects would throw any light on the structure and origin of vast masses of natural rock. The manner in which I prepared them was as follows: A small bead of borax was so saturated with the substance under examination at a high temperature, that it became opaque either on cooling or when slowly re-heated. It was again fused so as to be quite transparent, and then very slowly cooled over the flame. If properly managed, the excess of material held in solution at a high temperature slowly crystallised out, the form and character of the crystals depending on the nature of the substance and on the presence of other substances added to the bead as test reagents. By this means I proved that in a few exceptional cases small simple solid crystals are formed. More frequently they are compound, or occur as minute needles, but the most characteristic peculiarity is the development of complex skeleton crystals of extreme beauty, built up of minute attached prisms, so as to give rise to what would be a well-developed crystal with definite external planes, if the interspaces were all filled up. In many cases the fibres of these skeletons are parallel to three different axes perpendicular to one another, and it might be supposed that the entire skeleton was due to the growth of small needle-shaped crystals all uniformly elongated in the line of one crystalline axis, so that the resulting mass would be optically and crystographically complex; but in some cases the different systems of fibres or needles are inclined obliquely, and then the optical characters enable us to prove that the separate prisms are not similar to one another, but developed along different crystalline planes, so as to build up one definite crystal, mechanically complex, but optically and crystographically simple, or merely twinned. In a few special cases there is a well-pronounced departure from this rule, and truly compound groups of prisms are formed. In the centre, that is a definite simple prism; but instead of this growing continuously in the same manner, so as to produce a larger prism, its ends, as it were, break up into several smaller prisms, slightly inclined to the axis of the first; and these secondary prisms, in like manner, break up into still smaller, so as ultimately to give rise to a curious complex brush-like growth, showing in all positions a sort of fan-shaped structure, mechanically, optically, and crystographically complex.

I have done my best to describe these various kinds of crystals seen in blowpipe beads as clearly as can be done without occupying too much time, but feel that it is impossible to make the subject as simple as it really is without numerous illustrations. However, for the purpose now in view, it will, I trust, suffice to have established the fact that we may divide the crystals in blowpipe beads into the following groups, which on the whole are sufficiently distinct, though they necessarily pass one into the other.

1. Simple crystals
2. Minute detached needles.
3. Fan-shaped compound groups.
4. Feathery skeleton crystals.

It must not be supposed that crystals of one or other of these groups occur promiscuously and without some definite relation to the special conditions of the case. Very much depends upon their chemical composition. Some substances yield almost exclusively those of one group, and other substances those of another, whilst in some cases a difference in the rate of cooling and other circumstances give rise to variations within certain limits; and, if it were possible to still further vary some of the conditions, these limits would probably be increased. Thus, for example, the earliest deposition of crystalline matter from the glassy solvent is sometimes in the form of simple solid prisms or needles, but later on in the process it is in the form of compound feathery tufts; and if it were possible to cool the beads much more slowly whilst they are very hot, I am inclined to believe that some substances might be found that in the early stage of the process would yield larger and more solid crystals than those commonly met with. This supposition, at all events, agrees with what takes places when such salts as potassium chloride are crystallised from solution in water. Some of my blowpipe beads prove most conclusively that several perfectly distinct crystalline substances may be contemporaneously deposited from a highly heated vitreous solvent, which is an important fact in connection with the structure of igneous rocks, since some authors have asserted that more than one mineral species cannot be formed by the slow cooling of a truly melted rock. The great advantage of studying artificial blowpipe beads is that we can so easily obtain a variety of results under conditions which are perfectly well known, and more or less completely under control.

Artificial Slags.—I now proceed to consider the structure of slags, and feel tempted to enter into the consideration of the various minerals found in them which are more or less perfectly identical with those characteristic of erupted rocks; but some of the most interesting, like the felspars, occur in a well-marked form only in special cases where iron ores are smelted with fluxes, seldom, if ever, employed in our own country, so that my acquaintance with them is extremely small. My attention has been mainly directed to the more common products of our blast-furnaces. On examining these, after having become perfectly familiar with the structure of blowpipe beads, I could see at once that they are very analogous, if not identical in their structure. In both we have a glassy solvent, from which crystals have been deposited; only in one case this solvent was red hot, melted borax, and in the other glassy, melted stone. Thus, for example, some compounds, like what I believe is Humboldtilite, crystallise out in well-marked solid crystals, like those seen occasionally in blowpipe beads, whereas others crystallise out in complex feathery skeletons, just like those so common in and characteristic of the beads. In both we also often see small detached needles, scattered about in the glassy base. These skeleton crystals and minute needles have been described by various writers, under the names, *crystallites*, *belonites*, and *trichites*. Though we have not the great variety of different forms met with in the beads, and cannot so readily vary the conditions under which they are produced, yet we can, at all events, see clearly that their structural character depends both on their chemical constitution and on the physical conditions under which they have crystallised. None of my microscopical preparations of English slags appear to contain any species of felspar, but several contain what I believe is some variety of augite, both in the form of more or less solid prisms, and of feathery skeletons of great beauty and of much interest in connection with the next class of products to which I shall call your attention, viz., rocks artificially melted and slowly cooled.

Rocks Artificially Melted.—I have had the opportunity of preparing excellent thin microscopical sections of some of the results of the classic experiments of Sir James Hall. I have also carefully studied the product obtained by fusing and slowly cooling much larger masses of the basalt of Rowley, and have compared its structure with that of the original rock. Both are entirely crystalline, and, as far as I can ascertain, both are mainly composed of the same minerals. Those to which I would especially call attention are a triclinic felspar and an augite. The general character of the crystals is, however, strikingly different. In the artificial product a considerable part of the augite occurs as flat, feathery plates, like those in furnace slags, which are quite absent from the natural rock, and only part occurs as simple solid crystals, analogous to those in the rock, but much smaller and less developed. The felspar is chiefly in the form of elongated, flat, twinned prisms, which, like the prisms in some blowpipe beads, commence in a more simple form, and end in complex fan-shaped brushes, whereas in the natural rock they are larger than in the artificial, and exclusively of simple character. On the whole, then, though the artificially melted and slowly cooled basalt is entirely crystalline, and has a mineral composition closely like that of the natural rock, its mechanical structure is very different, being identical with that of blowpipe beads and slags.

Volcanic Rocks.—Passing now to true natural igneous rocks, we find some, like obsidian, which closely correspond with blowpipe beads, slags, and artificially melted rocks, in having a glassy base, through which small crystalline needles are scattered; but the more completely crystalline volcanic rocks have, on the whole, a structure very characteristically unlike that of the artificial products. I have most carefully examined all my sections of modern and ancient volcanic rocks, but cannot find any in which the augite or magnetite is crystallized in feathery skeletons. In the case of only one single natural rock, from a dyke near Beaumaris, have I found the triclinic felspar arranged in just the same fan-shaped, brush-like groups as those in similar rocks artificially melted and slowly cooled. The large solid crystals in specimens from other localities sometimes show that towards the end of their growth small flat prisms were developed on their surface, analogous to those first deposited in the case of the artificial product. In slags composed almost exclusively of what I believe is Humboldtilite, the crystals are indeed uniformly as simple and solid as those in natural rocks, but the examination of different blowpipe beads shows that no fair comparison can be made between altogether different substances. We must compare together the minerals common to the natural and the artificial products, and we then see that, on the whole, the two classes are only just distinctly connected by certain exceptional crystals and by structural characters which, as it were, overlap enough to show that there is a passage from one type to the other. In the artificial products are a few small, solid crystals of both augite and a triclinic felspar, which closely correspond to the exceptionally small crystals in the natural rocks; but the development of the great mass of the crystals is in a different direction in the two cases. In the artificial products it is in the direction of complex skeletons, which are not seen in the natural rock; but in the natural rock it is in the direction of large simple solid crystals, which are not met with in the artificial products. There is a far closer analogy in the case of partially vitreous rocks, which, independent of the true glassy base common to them and the artificial products, often contain analogous crystalline needles. Even then, however, we see that in the artificial product the crystals tend to develop into complex skeletons, but in the natural rocks into simple solid crystals.

It must not be supposed that these facts in any way lead me to think that thoroughly crystalline modern and ancient volcanic rocks were never truly fused. The simple, large, and characteristic crystals of such minerals as augite, felspar, leucite, and olivine, often contain so many thoroughly well-marked glass enclosures, as to prove most conclusively that when the crystals were formed they were surrounded by, and deposited from, a melted glassy base, which was caught up by them whilst it was still melted. This included glass has often remained unchanged, even when the main mass became completely crystalline, or has been greatly altered by the subsequent action of water. I contend that these glass enclosures prove that many of our British erupted rocks were of as truly igneous origin as any lava flowing from a modern volcano. The difference between the structure of such natural rocks and that of artificial slags must not, in my opinion, be attributed to the absence of true igneous fusion, but to some difference in the surrounding conditions, which was sufficient to greatly modify the final result, when the fused mass became crystalline on cooling. The observed facts are clear enough, and several plausible explanations might easily be suggested, but I do not feel at all convinced that any single one would be correct. That which first suggests itself is a much slower cooling of the natural rocks than is possible in the case of the artificial products; and I must confess that this explanation seems so plausible that I should not hesitate to adopt it, if certain facts could be accounted for in a satisfactory manner. Nothing could be more simple than to suppose that skeleton crystals are formed when deposition takes place in a hurried manner, and they so overgrow the supply that they develop themselves along certain lines of growth before there has been time to solidly build up what has been roughly sketched in outline. I cannot but think that this must be a true and, to some extent, active cause, even if it be inadequate to explain all the facts. What makes me hesitate to adopt it by itself is the structure of some doleritic rocks when in close contact with the strata amongst which they have been erupted. In all my specimens the effects of much more rapid cooling are perfectly well marked. The base of the rock when in close contact is sometimes so extremely fine-grained that it is scarcely crystallised, and is certainly far less crystalline and finer-grained than the artificial products to which I have called attention, and yet there is no passage towards those structures which are most characteristic of slags, or at least, no such passage as I should have expected if these structures depended exclusively on more rapid cooling.

We might well ascribe something to the effect of mass, but one of my specimens of basalt melted and slowly cooled in a small crucible is quite as crystalline as another specimen taken from a far larger mass, though I must confess that what difference there is in this latter is in the direction of the structure characteristic of natural rocks. The presence or absence of water appears to me a very probable explanation of some differences. When there is evidence of its presence in a liquid state during the consolidation of the rock we can scarcely hesitate to conclude that it must have had some active influence; but in the case of true volcanic rocks the presence of liquid water is scarcely probable. That much water is present in some form or other, is clearly proved by the great amount of steam given off from erupted lavas. I can scarcely believe that it exists in a liquid state, except at great depths, but it may possibly be present in a combined form or as a dissolved vapour under much less pressure, and the question is whether this water may not have considerable influence on the growth of crystals formed prior to eruption, before it was given off as steam. I do not know one single fact which can be looked upon as fairly opposed to this supposition, and it is even to some extent supported by experiment. M. Daubrée informs me that the crystals of augite formed by him at a high temperature by the action of water have the solid character of those in volcanic rocks, and not the skeleton structure of those met with in slags. The conditions under which they were formed were, however, not sufficiently like those probably present during the formation of erupted lavas to justify our looking upon the explanation I have suggested as anything more than sufficiently plausible, in the absence of more complete experimental proofs.

Granitic Rocks.—I now proceed to consider rocks of another extreme type, which for distinction we may call the granitic. On the whole, they have little or nothing in common with slags, or with artificial products similar to slags, being composed exclusively of solid crystals, analogous in character only to slag-crystals of very different mineral nature. As an illustration, I would refer to the structure of the products formed by fusing and slowly cooling upwards of a ton of the syenite of Grooby, near Leicester. Different parts of the resulting mass differ very materially, but still there is an intimate relation between them, and a gradual passage from one to the other. The most characteristic feature of those parts which are completely crystalline is the presence of beautiful feathery skeleton-crystals of magnetite, and of long flat prisms of a triclinic felspar, ending in complex, fan-shaped brushes. There are no solid crystals of felspar, hornblende, and quartz, of which the natural rock is mainly composed, to the entire exclusion of any resembling those in the melted rock. As looked upon from the point of view taken in this address, the natural and artificial products have no structural character in common, so that I think we must look for other conditions than pure igneous fusion to explain the greatly modified results. We have not to look far for evidence of a well-marked difference in surrounding circumstances. The quartz in the natural rock contains vast numbers of fluid-cavities, thus proving that water was present, either in the liquid state or as a vapour so highly compressed that it afterwards condensed into an almost equal bulk of liquid. In some specimens of granite there is indeed clear proof that the water was present as a liquid, supersaturated with alkaline chlorides, like that inclosed in the cavities of some minerals met with in blocks ejected from Vesuvius, which also have to some extent what may be called a granitic structure. In the case of one very exceptional and interesting granite, there is apparently good proof that the felspar crystallised out at a temperature above the critical point of water—that is to say, at a temperature higher than that at which water can exist as a liquid under any pressure—and it caught up highly compressed steam, comparatively, if not entirely, free from soluble salts; whereas the quartz crystallised when the temperature was so far lowered as to be below the critical point, and the water had passed into a liquid, supersaturated with alkaline chlorides, which have crystallised out as small cubes in the fluid-cavities, just as in the case of minerals in some of the blocks ejected from Vesuvius.

Confining our attention, then, to extreme cases, we thus see that rocks of the granitic type differ in a most characteristic manner from the products of artificial igneous fusion, both in the structure of the crystals and in containing liquid water, inclosed at the time of their formation. The question then arises, whether these differences were due to the presence of the liquid water, or whether its presence and the characteristic structure were not both the effects of the great pressure of superincumbent rocks. I do not see how this can be decided in a perfectly satisfactory manner, but must confess that I am inclined to believe that, whilst great pressure was necessarily the reason why the water did not escape as vapour, the presence of liquid water during final consolidation must have had a very considerable influence in modifying the structure of the rock, and had a great share in developing what we may call the granitic type.

It would be very instructive to follow out the gradual passage from one extreme type to another far more completely than is possible on the present occasion. The most interesting examples of rocks intermediate between the granitic and volcanic types that I have been able to examine in adequate detail, are the various Cornish elvans and other quartz felsites, which furnish all but a complete passage from pitchstone to granite. Some specimens prove that quartz may crystallize out from and inclose a perfectly glassy base, without a trace of liquid water; and at the same time other specimens prove equally well that, as we approach the granitic type, the quartz was not deposited from a glassy solvent, but inclosed more or less water. In the few intermediate cases there appears to be evidence of the conjoint presence of uncombined water and melted stony matter. On the whole, if we take into consideration only the external form of the larger crystals, rocks of the granitic type are very much as though the crystals met with in truly volcanic rocks had been strained out from the glassy or fine-grained base, and the intermediate spaces filled with quartz. The internal structure of the crystals is, however, very different, the cavities in one class containing glass, and in the other water. This most essential and characteristic difference proves that rocks of the true granitic type cannot have been formed simply by the more complete crystallization of the general base of the rock. If the crystals in granite were analogous to those developed in volcanic rocks, and the only essential difference were that the residue crystallized out more slowly and completely, so as to give rise to a more coarsely crystallized base, the crystals first formed ought not, as I think, to differ so essentially as that in one case they should inclose only glass, and in the other only water. Taking all into consideration, we can therefore scarcely suppose that the crystals in granitic rocks were deposited from a truly melted, dry, glassy solvent, like those in volcanic rocks or in slags.

General Results.—I have, I trust, now said enough to show that the objects here described may be conveniently separated into three well-marked groups, viz., artificial slags, volcanic rocks, and granitic rocks. My own specimens all show perfectly well-marked and characteristic structures, though they are connected in some cases by intermediate varieties. Possibly such connecting links might be more pronounced in other specimens that have not come under my notice. I must, however, base my conclusions on what I have been able to study in an adequate manner, by examining my own preparations, and leave it for others to correct any errors into which I may have been led from lack of more numerous specimens. In any case the facts seem abundantly sufficient to prove that there must be some active cause for such a common, if not general, difference in the structural character of these three different types. The supposition is so simple and attractive, that I feel very much tempted to suggest that this difference is due to the presence or absence of water as a gas or as a liquid. In the case of slags it is *not* present in *any* form. Considering how large an amount of steam is given off from erupted lavas, and that, as a rule, no fluid-cavities occur in the constituent minerals, it appears to me very plausible to suppose that those structures which are specially characteristic of volcanic rocks are in a great measure, if not entirely, due to the presence of *associated* or *dissolved vapour*. The fluid-cavities prove that water was sometimes, if not always, present as a *liquid* during the consolidation of granitic rocks; and we can scarcely hesitate to conclude that it must have had very considerable influence on the rock during consolidation. Still, though these three extreme types appear to be thus characterised by the absence of water, or by its presence in a state of vapour or liquid, I think we are scarcely in a position to say that this difference in the conditions is more than a plausible explanation of the differences in their structure. At the same time, I do not know any facts that are opposed to this conclusion, and we should, perhaps, not greatly err in thus correlating the structures, even though the water was not the essential and active cause of the differences.

Confining our attention to the more important crystalline constituents which are common to the different types, we may say that the chief structural characters of the crystals are as follows:—

a. Skeleton crystals.	*d.* Simple crystals.
b. Fan-shaped groups.	*e.* Fluid-cavities.
c. Glass-cavities.	

These different structural characters are found combined in different ways in the different natural and artificial products; and for simplicity I will refer to them by means of the affixed letters.

The type of the artificial products of fusion may generally be expressed by $a + b$ or $b + c$, that is to say, it is characterised by skeleton crystals and fan-shaped groups, or by fan-shaped groups and glass-cavities. In like manner the volcanic type may be expressed occasionally by $b + c$, but generally by $c + d$; and the granitic by $d + e$. These relations will be more apparent if given in the form of a table, as follows:—

Slag type . .	$a + b$, $b + c$
Volcanic type . .	$b + c$, $c + d$
Granitic type	$d + e$.

Hence it will be seen that there is a gradual passage from one type to the other by the disappearance of one character and the appearance of another, certain characters the meanwhile remaining common, so that there is no sudden break, but an overlapping of structural characteristics. It is, I think, satisfactory to find that, when erupted rocks are examined from such a new and independent point of view, the general conclusions to which I had been led are so completely in accord with those arrived at by other methods of study.

Conclusion.—And now I feel that it is time to conclude. I have necessarily been compelled to give only a general account of the subject, and perhaps, for want of adequate description, many facts may appear more complex than they really are. Some are, indeed, of anything but simple character, and their full explanation is, perhaps, beyond our present power. The greater part are, however, much more simple and easy to observe than to describe; and, even if I have failed to make everything as plain as I could wish, I hope I have succeeded in making the principal point sufficiently clear to show that the structure of slags and of analogous artificial products throws much light on the structure and origin of the various groups of erupted rocks. I feel that very much still remains to be learned, and, as I think, could be learned, by the further extension of this method of inquiry. What strikes me most is the great necessity for the more complete application of experimental methods of research; but to carry out the experiments necessary to clear up the essential difficulties of the subject would, I fear, be a most difficult undertaking. In the meantime all that we can do is to compare the structure of known artificial products with that of natural rocks, and to draw the best conclusions we can from the facts, as viewed in the light of our present knowledge of chemistry and physics. My own impression is that there is still much to be learned respecting the exact conditions under which some of our commonest rocks were formed.

REVIEWS.

I.—British Association for the Advancement of Science, Swansea, August 26, 1880.

It has seldom, if ever, happened before, that the meeting of the British Association has been inaugurated by a purely geological address from its President.

Whatever may have been that President's special line of study, it has generally been the practice to furnish some retrospect of the work carried on in all the various branches of scientific research—*besides geology.* This year, however, the President, Prof. A. C.

Ramsay, LL.D., F.R.S., V.P.G.S., has entirely ignored his character as "*the Chief of many Sections*," and has devoted his Address simply to his favourite study—geology. His text is "On the Recurrence of Certain Phenomena in Geological Time," and may be considered as a strictly *Uniformitarian* discourse. As the "Times" and every other paper has given it more or less in full, we need not attempt a task quite beyond our space here. The subjects chosen to illustrate the proposition were "*Metamorphism;*" "*Volcanos;*" "*Mountain Chains;*" "*Salt and Salt-Lakes;*" "*Fresh-water*"—"*Lakes and Estuaries;*" "*Glacial Phenomena.*" We can only find space for the Conclusion, which we give in Prof. Ramsay's own words:—

"In opening this address, I began with the subject of the oldest metamorphic rocks that I have seen—the Laurentian strata. It is evident to every person who thinks on the subject that their deposition took place *far from the beginning of recognized geological time.* For there must have been older rocks by the degradation of which they were formed. And if, as some American geologists affirm, there are on that continent metamorphic rocks of more ancient dates than the Laurentian strata, there must have been rocks more ancient still to afford materials for the deposition of these pre-Laurentian strata.

Starting with the Laurentian rocks, I have shown that the phenomena of *metamorphism* of strata have been continued from that date all through the later formations, or groups of formations down to and including part of the Eocene strata in some parts of the world.

In like manner I have shown that ordinary volcanic rocks have been ejected in Silurian, Devonian, Carboniferous, Jurassic, Cretaceo-oolitic, Cretaceous, Eocene, Miocene, and Pliocene times, and from all that I have seen or read of these ancient volcanos, I have no reason to believe that volcanic forces played a more important part in any period of geological time than they do in this our modern epoch.

So, also, mountain-chains existed before the deposition of the Silurian rocks, others of later date before the Old Red Sandstone strata were formed, and the chain of the Ural before the deposition of the Permian beds. The last great upheaval of the Alleghany Mountains took place between the close of the formation of the Carboniferous strata of that region and the deposition of the New Red Sandstone.

According to Darwin, after various oscillations of level, the Cordillera underwent its chief upheaval after the Cretaceous epoch, and all geologists know that the Alps, the Pyrenees, the Carpathians, the Himalayas, and other mountain-chains (which I have named) underwent what seems to have been their chief great upheaval after the deposition of the Eocene strata, while some of them were again lifted up several thousands of feet after the close of the Miocene epoch.

The deposition of salts from aqueous solutions in inland lakes and lagoons appears to have taken place through all time—through Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Eocene, Miocene, and Pliocene epochs—and it is going on now.

In like manner fresh-water and estuarine conditions are found now in one region, now in another, throughout all the formations or groups of formations possibly from Silurian times onward; and glacial phenomena, so far from being confined to what was and is generally still termed *the* Glacial Epoch, are now boldly declared, by independent witnesses of known high reputation, to begin with the Cambrian epoch, and to have occurred somewhere, at intervals, in various formations, from almost the earliest Palæozoic times down to our last post-Pliocene 'Glacial Epoch.'

If the nebular hypothesis of astronomers be true (and I know of no reason why it should be doubted), the earth was at one time in a purely gaseous state, and afterwards in a fluid condition, attended by intense heat. By-and-by consolidation, due to partial cooling, took place on the surface, and as radiation of heat went on, the outer shell thickened. Radiation still going on, the interior fluid matter decreased in bulk, and, by force of gravitation, the outer shell being drawn towards the interior, gave way, and, in parts, got crinkled up, and this, according to cosmogonists, was the origin of the earliest mountain-chains. I make no objection to the hypothesis, which, to say the least, seems to be the best that can be offered, and looks highly probable. But, assuming that it is true, these hypothetical events took place so long before authentic geological history began, as written in the rocks, that the earliest of the physical events to which I have drawn your attention in this address was, to all human apprehension of time, so enormously removed from these early assumed cosmical phenomena, *that they appear to me to have been of comparatively quite modern occurrence, and to indicate that from the Laurentian epoch down to the present day, all the physical events in the history of the earth have varied neither in kind nor in intensity from those of which we now have experience.* Perhaps many of our British geologists hold similar opinions, but, if it be so, it may not be altogether useless to have considered the various subjects separately on which I depend to prove the point I had in view."

II.—United States Geological and Geographical Survey of Colorado and Adjacent Territory, 1876. By F. V. Hayden, United States Geologist. 8vo. (Published at the Government Printing Office, Washington, 1878.)

The Tenth Annual Report of this extensive and exhaustive Survey is fully worthy of its predecessors, and bears testimony that there is no want of care, attention, and energy on the part of the Department over which Mr. Hayden has presided.

It contains the subsidiary reports of Messrs. C. A. White, F. M. Endlich, and A. C. Peale, on the Geology of a portion of North-Western Colorado, the White River Division, and the Grand River district; and reports also on the triangulation and survey of the districts under examination, the value of the arable and pasture land for cultivation, and a most interesting treatise on the archæological remains.

The Geological series described embraces the Tertiaries of Unita, Bridger, Green River, and Wahsatch, comprising beds of coarse friable sandstones and conglomerates; the Post-Cretaceous of Laramie, containing carbonaceous layers and beds of coal, intercalated with reddish, ferruginous, and yellowish sandstones; the Cretaceous beds of Fox Hills, Colorado, and Dakota, containing clayey and sandy shales; the Jura-Trias of different coloured sandstones, with calcareous fossiliferous rock; and lastly the Carboniferous strata, consisting of sandy and calcareous beds, with masses and nodules of chert, compact bluish fossiliferous limestone, sandstones, sandy limestones, and hard and often quartzitic brick-red sandstones. These rest on the Weber quartzite. The sections and outline illustrations of these strata are most admirably rendered; and a further series of sketches of the weathered and eroded sandstones forming "monuments," such as the "Happy Family" group in the White River Cañon, are also given. Speaking of the latter, Mr. Endlich observes, "The most frequent form exhibited is one closely imitating ruins of some ancient building or city. Seen by the slanting rays of a setting sun, the hills seem fortified, each by a castle of enormous dimensions, that throws a long-drawn shadow to the eastward. Turrets and battlements are supplied by the skilful hand of nature, that teach, by their form, the source whence human ingenuity copied them."

It is also advanced that, though the cañons have been mainly carved out by water-action alone, there seem to be indications of ice-action in the marking out of their original directions, though the softness and friability of the rock materials would prevent any direct traces being found now.

An excellent monograph on the erupted rocks of Colorado, and a catalogue of the minerals found in Colorado, add much to the value of the volume; but perhaps the most interesting portion is that contributed by Mr. William H. Holmes, on the archæology of the districts surveyed. They seem even more extensive than those previously described, but occupy the same positions as in other parts of the Colorado, that is, rock-shelters and caves, situated high up on the steep sides of the valleys, and improved by the addition of masonry into terraces, walls, and houses. Although the country is, generally speaking, dry and barren, and seems almost incapable of supporting a population so extensive, apparently, as that which originally occupied it, the streams and springs, near which the remains are exclusively found, are bordered by grass-covered bottoms and alluvial tracts; and these, if perfectly utilized, would afford a considerable area of rich tillable land.

As a rule, the buildings are of regular form, that is (where the ground permits), either in perfect circles or perfect squares; and in the larger towers the space between the outer walls is divided by heavy partition-walls into a number of apartments, with a circular depression or *Estufa* (or council-house) in the centre. Quantities of flint chips, and fragments of pottery, were found in the neighbourhood of the habitations. The fictile fragments are richly marked, in black or red, on a greyish or yellowish ground, with lined or geometric patterns; while in many cases the clay vessel was rudely modelled into the form of birds.

One skull, found in the Chaco Cañon, among ruins situated on the alluvial floor of the valley, is believed to have belonged to the ancient Pueblo Indian race. It is that of a female. The most striking feature of the cranium being the great flattening of its posterior portion, "including the anterior portion of the occipital and the posterior-superior portions of the parietal bones." From the appearance of the bones this does not appear to have been a post-mortem deformation.

Numerous pictorial rock-inscriptions are either chipped into the rock or painted in white or red clay; but among the numerous figures so depicted are none that resemble the horse.

The volume concludes with a lengthy catalogue of the Cretaceous and Tertiary plants of North America. C. Cooper King, F.G.S.

III.—Report on the Geology of the Henry Mountains. By G. K. Gilbert. (Washington, 1877.)

Ten years previous to the publication of this work, the district described therein was comparatively unknown, no mention being made of it in any of the published accounts of exploration in the Rocky Mountain region. The name of Henry Mountains was given by Prof. Powell during his journey in 1869 down the Colorado, on the right bank of which river they are situated between two of its tributaries, the Dirty Devil and the Escalante. Although occasionally visited, no regular survey of these mountains was made until that undertaken in 1875–76 by Mr. H. G. Graves and the author of this volume.

The Henry Mountains do not form a continuous range, but consist of a series of five isolated mountains (described in chapter ii.) rising from the plain below to heights varying from 1500 to 5000 feet; the general elevation averages about 11,000 feet above the sea-level. They consist of Cretaceous, Jura-Trias, and Carboniferous strata, with associated intrusive masses and veins of trachyte. It is to the manner in which the trachyte has intruded into, and affected the sedimentary strata, that the peculiar physiognomy of their present appearance is primarily due, and which is fully described in the chapter on "The Laccolite." According to the author the trachytic lava, "instead of rising through all the beds of the earth's crust, stopped at a lower horizon, insinuated itself between two strata, and opened for itself a chamber by lifting all the superior beds. In this chamber it congealed, forming a massive body of trap." For this body the name *laccolite* (λακκος, *cistern*, λιθος, stone) has been used.

The dome-shaped elevation of the original horizontal strata, by the injection from below of a mass of molten matter, has produced the type of structure exemplified in the Henry Mountains, modified of course as to the surface features by the various subaerial agencies which have acted since their upheaval, the effects of which agencies Mr. Gilbert has clearly treated under the head of Land Sculpture.

The work will form a useful addition to our knowledge of that portion of the Colorado plateau, containing as it does suggestive remarks and deductions possessing much novelty as to the origin and combination of the causes which have influenced the land sculpture of the district, so fully illustrated in the numerous woodcuts and maps which accompany the volume. J. M.

REPORTS AND PROCEEDINGS.

THE GEOLOGICAL SOCIETY OF FRANCE.

THE Geological Society of France held their annual meeting at Boulogne during the past month, extending from the 9th to the 18th of September. Prof. Prestwich, M.A., F.R.S., was elected President of the meeting. The programme for the ten days comprised a series of interesting and well-arranged excursions, in which all the important points in the geology of the Boulonnais were fully explored, including the examination of the Devonian, Carboniferous, Jurassic, Cretaceous, and Tertiary strata.

To render these daily excursions more instructive, the printed programme was accompanied by four descriptive sections: 1, showing the sequence of the Palæozoic rocks from Blecquenecques to Caffiers; 2, the cliff section from Alpreck to Wimereux; 3, the Middle and Upper Jurassics as exposed in the coast section from Echingen to la Crêche; 4, the Cretaceous series as shown along the cliffs from Wissant to Sangatte, with the overlying Quaternary deposit at the latter place. Prof. Prestwich read a paper on the Sangatte Cliff, in which he brought before the meeting the views he advanced in his paper recently read at Swansea. The meeting was well attended, and the members were hospitably entertained by the municipality, etc. Among those present were, MM. Lapparent, Sauvage, Gosselet, Vaillant, Pellat, Rutot, Van der Broeck, Cornet, Briart, Donville, and Rigaux.

It is forty-one years since the Society held their last meeting at Boulogne, when Dr. Fitton was the President. J. M.

CORRESPONDENCE.

THE GLUTTON IN BRITAIN.

SIR.—The following statement occurs in the second paragraph of Mr. Newton's "Notes on the Vertebrata of the Pre-Glacial Forest Bed Series of the East of England" (GEOL. MAG., No. 195, p. 424, Sept. 1880):—"The occurrence of the Glutton in Britain was first intimated by MM. Boyd Dawkins and Sanford in the year 1866."

There was, however, an earlier intimation of a British Glutton. The late Mr. J. C. Bellamy, surgeon, in his "Natural History of South Devon," published in 1839, gives a description of the well-known cavern at Yealm Bridge, about seven miles E.S.E. of Plymouth, which he had investigated with considerable care, and mentions the Glutton amongst the rarer animals represented by the remains found there (see pp. 89, 94, and 102; see also Trans. Devon Assoc., vol. iv. pp. 98, 102). WM. PENGELLY.

TORQUAY, 16*th September*, 1880.

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Of the materials collected, during many years of research, some portion has been already utilised in a Lecture delivered by the author before the 'Hertfordshire Natural History Society,' in October, 1879, *and in several articles in the 'Popular Science Review' and the natural history columns of 'The Field.'*

The exigencies of time and space, however, necessitated a much briefer treatment of the subject in the journals referred to than is here attempted, and to these essays, now presented to the reader in a consolidated form, considerable additions have been made.

That the subject admits of still further amplification the author is well aware; but 'ars longa vita brevis est,' *and the materials at present collected have already assumed such dimensions, that it has been deemed preferable to offer them to the reader in their present form, rather than postpone publication indefinitely, in the hope of some day realizing an ideal state of perfection.*

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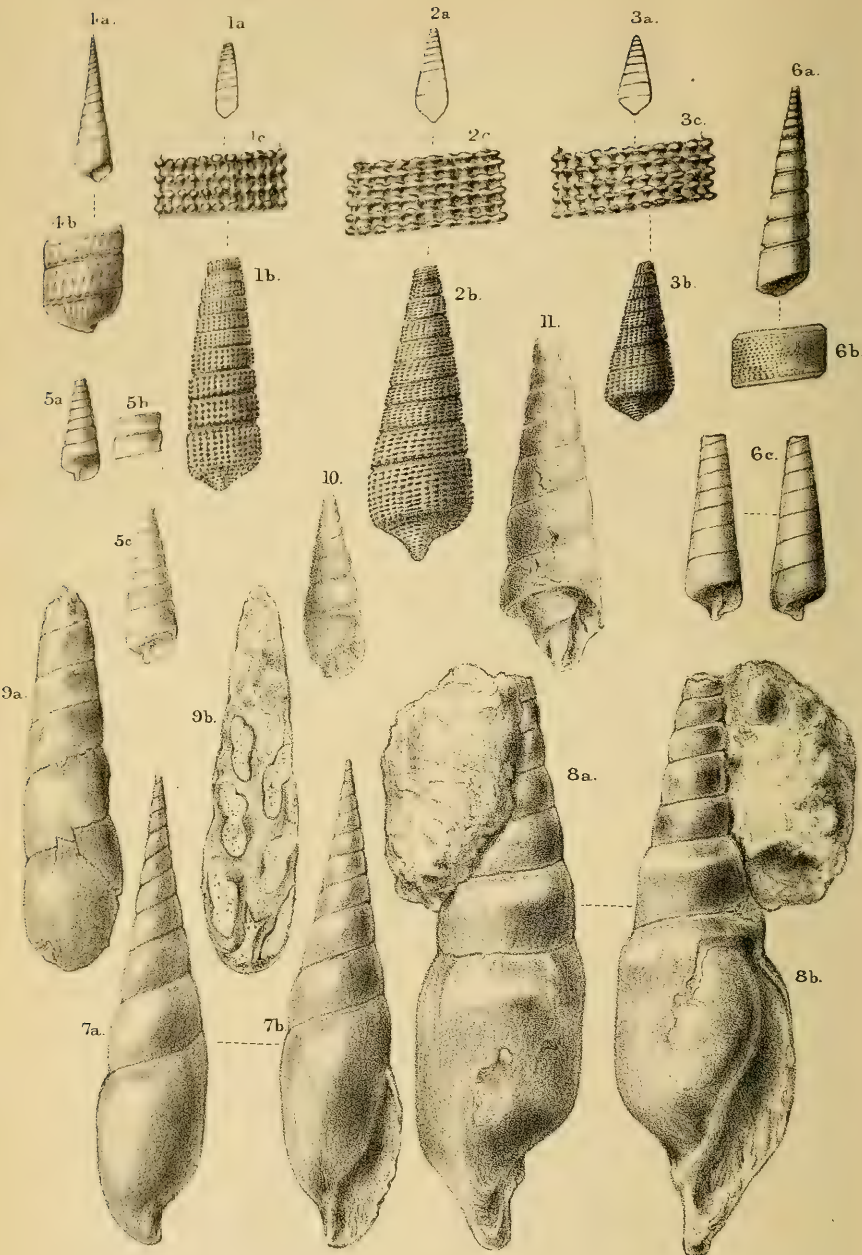

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No. XI.—NOVEMBER, 1880.

ORIGINAL ARTICLES.

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

Part IV.

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

(PLATE XVI.)

Group allied to Cerithium limæforme, Rœm., 1836. Plate XVI. Figs. 1–3.

Cerithium limæforme, Rœm., Ool. Geb., tab. xi. fig. 19, p. 142.

Bibliography, etc.—This is just one of those cases where it is so difficult to choose between accepting names for forms which, though allied, are distinct, or simply lumping all the forms together under one specific designation, which does not exactly fit any of them. Objections more or less valid may be urged against either course, and some might be disposed to cut the Gordian knot by making new species all round. Buvignier went very closely into the varieties of the Corallian *Cerithia*. He points out that the true *C. limæforme* of Rœmer occurs rather higher than the Coral Rag, viz. in the "calcaire à astartes," to which it is restricted. It is characterized by *three* rows of transverse granulations, just as shown in Rœmer's enlarged figure, though at times a fourth or even a fifth very faint one is developed. It is difficult to say of what value these refinements may be, but certainly *C. limæforme,* as thus restricted, cannot be exactly identified in the Corallian of Yorkshire, where its place is occupied by forms slightly different, though in our collections they have been generally lumped together under the heading *C. limæforme,* Rœmer.

In North Germany, Brauns is disposed to take the same view, and he regards Buvignier's Coral Rag species, *C. grandineum* and probably *C. Humbertinum,* as identical with Rœmer's species. Nevertheless it is curious that forms something very like these, though not exactly, do occur in our Coral Rag. The three following have been selected for illustration, and correlated approximately.

19.—Cerithium near to limæforme, Rœm., as restricted by Buvignier. Pl. XVI. Figs. 1*a*, *b*, *c*.

Cerithium limæforme, Rœm., Buvignier, Stat. Géol. de la Meuse, p. 41, pl. iv. fig. 3.

Description.—Specimen from the Coralline Oolite of Ness (my Collection).

Length	11 millimètres.
Width	3 ,,
Spiral angle	Convex.

[1] Continued from the September Number, p. 404.

Shell narrow, subturrited. Spiral angle moderately convex, imparting a slightly pupoid character. Whorls about eleven in number, ornamented with close roundish granulations, which result from the decussation of the spiral with the transverse ribbing, the intervening mesh being almost square. On the flank of the last and penultimate whorls the transverse costæ are four in number (see Fig. 1*c*, which represents an enlargement of the penultimate whorl). In the two preceding whorls the fourth row is fainter than the others. In the remaining whorls no more than three costæ are visible. The whorls are well separated, the suture being tolerably deep and wide for a shell of this class. Aperture involved in matrix.

Relations and Distribution.—This shell seems to be intermediate between the older *C. quadricinctum*, Goldf., and the regular *C. limæforme*, Rœm., which, according to Buvignier, should occur above the Coral Rag. The form under description, but with variations, is pretty common in the Coral Rag of the Scarborough district (Seamer, Ayton, Brompton), but is comparatively rare in the Coralline Oolite of Yorkshire.

20.—Cerithium, near to grandineum, Buvignier, 1852. Plate XVI. Figs. 2*a*, *b*, *c*.

Cerithium grandineum, Buv., 1852, Statis. Géol. de la Meuse, p. 40, pl. iv. fig. 2.

Buvignier's description and enlarged figures are satisfactory. The points wherein the species differs from the restricted *C. limæforme* are obvious. Buvignier's description of *C. grandineum* tallies better with our shell than does his figure.

Description.—Specimen from the Coral Rag of the Scarborough district (Leckenby Collection).

Length	14 millimètres.
Greatest width	4·5 ,,
Spiral angle	Convex.

Shell elongated, slightly turrited; spire tolerably sharp. Whorls about thirteen in number; rather flat, richly ornamented, and increasing at first under an angle of 23° (?), but becoming closer afterwards. The whorls are crowded together with very little space for the sutures. The ornaments consist of an interlacing network of granulated ribbing, which is arranged so closely as to produce a characteristic appearance. The longitudinal costæ incline but slightly from the axis of the spire; these decussate with transverse granulated costæ six in number, of nearly the same degree of prominence (Fig. 2*c*). The nodes at the intersections are not spiny, but are drawn out in the direction of the transverse ribbing, which alone is continued in the base of the shell. Aperture concealed in matrix.

Relations and Distribution.—If Buvignier's figure is correctly enlarged, the granulations in his specimen are much finer than in the Yorkshire shell; in other respects there is a considerable similarity. In Yorkshire this species, or variety, does not seem to be common, though there are specimens in the Coral Rag of Ayton, etc., which approach it.

21.—Cerithium, near to Humbertinum, Buvignier, 1852. Plate XVI. Figs. 3*a*, *b*, *c*.

Cerithium Humbertinum, Buv., 1852, Statis. Géol. de la Meuse, p. 41, pl. xxviii. fig. 3.

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

Length	10·5 millimètres.
Width	4·5 „
Spiral angle	Convex.

Shell short, pupoid, and rather stout. The state of preservation is unfavourable for accurate description of the spire. The whorls are probably nine or ten in number, and seem rather closely set. The ornament consists of a fine network of granulations, the number of transverse rows being apparently five, of which one is fainter than the others (see Fig. 3*c*). The nodes are not round as in Figure 1*c*, but are drawn out transversely. The pillar at the base of the shell is just visible, but the aperture is indistinct.

Relations and Distribution.—Whatever may be thought of the correlation with Buvignier's species, the dimensions of this shell clearly separate it from the more ordinary forms of the *limæforme*-group. It is rare, and the specimen figured is the best known to me, but I have seen indications in the Ayton-Brompton Coral Rag of a short pupoid *Cerithium*, and once had an excellent specimen, which unfortunately was lost. I have a somewhat similar shell from the Coral Rag of Faringdon.

N.B.—The enlarged Figure 3*b* is a restoration. In Figure 1*b* only four transverse costæ should appear on the flank of the whorl, the remaining granulations are on the base.

22.—Cerithium bicinctum, sp.n. Plate XVI. Figs. 4*a*, *b*.

Description.—Specimen from the Coral Rag, probably of Langton Wold (Leckenby Collection).

Length	20 millimètres.
Width	5·5 „
Spiral angle	16°.

Shell elongated, conical, slightly turrited, sharply pointed. Spire consists of eighteen whorls, which increase under a regular angle of 16°. They are nearly flat, and but slightly separated by the suture. The ornaments, though faintly sculptured, are sufficiently characteristic, and become somewhat more pronounced in the anterior whorls. On the upper edge of each whorl is an irregular circle of faint granulations rather wide apart: below this the whorl is faintly ribbed spirally, and at wide intervals: towards the base, extending over about one-third of the height of the whorl, are two granulated lines. All these ornaments have about the same degree of prominence, the result being a delicately marked and very elegant shell. The base of the last whorl exhibits very fine regular transverse lines, which decussate with more wavy and irregular lines of growth. The aperture is somewhat imperfect, but is probably subquadrate with a short canal.

Relations and Distribution.—This species is sufficiently near to

C. Michaelense, Buv. (Statis. Géol. de la Meuse, p. 41, pl. xxvii. fig. 30), a shell stated to be rare in the White Oolite of the Coral Rag of St. Michel. The specimen now figured and described is unique, unless indeed a small specimen found in the Coral Rag of Sproxton, and referred to *C. Michaelense*, belong to the same species.

23.—Cerithium gradatum, sp.n. Plate XVI. Figs. 5*a*, *b*, *c*.

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

Length	16 millimètres.
Width	5 "
Spiral angle, convex, average	18°.

Shell but slightly elongated, strongly turrited. Spire consists of about eleven or twelve whorls, which are arranged in steps, imparting a character to the shell suggestive of the name: they are without visible ornament. The upper half of each whorl is prominent, whilst the lower half presents a flat and shallow depression, which serves to accentuate the step-like character of each whorl. The aperture is subquadrate.

Relations and Distribution.—Except as regards size this shell has a considerable resemblance to a large species named by Buvignier (*op. cit.* p. 41, pl. xxvii. figs. 13 and 14) *C. Verdunense*, from the Upper Coral Rag of Verdun. In the "Corallian Rocks of England" a similar fossil from the Coralline Oolite of Ness was so referred, but the alternative name *gradatum* was suggested.[1] It is rare.

24.—Cerithium inornatum, Buvignier, 1852. Plate XVI. Figs. 6*a*, 6*c*.

Cerithium inornatum, Buv., 1852, Statis. Géol. de la Meuse, p. 41, plate xxvii. figs. 17 and 18.

Bibliography, etc.—Buvignier's species does not seem to have been noted elsewhere on the Continent under that name, though perhaps *C. autissiodorense*, Cotteau, is not so very unlike (see L. & P., Ét. Supr. Jurass. p. 70, pl. vii. fig. 14). The Yorkshire shell has probably been regarded as a *Eulima*, and it is just possible that the *Chem.* (*Terebra*) *melanioides*, Phillips (G. Y. pl. iv. fig. 13), may have been intended for it.

Buvignier himself seems to have had some doubt as to the generic classification of his shell, since the aperture was not completely entire. Though not shown in his figure, he observes "on voit des traces de stries transverses."

Description.—*Figs.* 6 *a*, *b*. Specimen from the Coral Rag of Seamer (Strickland Collection).

Length restored	33 millimètres.
Width	8 "
Spiral angle	14°.

Shell elongated, conical, scarcely turrited. Spire consists of about thirteen very flat whorls, which increase under a regular angle of 14°. These whorls succeed each other like so many straps, the regularity of increase being very remarkable. In this specimen, which is well preserved in calcite, the whorls are slightly bevelled off at

[1] Quart. Journ. Geol. Soc. vol. xxxiii. p. 394.

the base, so as to accentuate the suture, but in the majority of cases this feature is less obvious.

Though apparently without ornament, closer examination reveals a very fine transverse striation (Fig. 6*b*), which varies according to the accidents of preservation. In this specimen it is seen only on the lower whorls, but in some specimens may be observed to extend much further up the spire. Aperture involved in matrix.

Fig. 6*c*. Another specimen from the Coral Rag of Brompton (my Collection).

The dimensions are proportionate to those of the preceding specimen, but the sutures are much less deep owing to wear, and all traces of the fine striation are lost. The *Cerithium*-like character of the aperture is well shown. In this condition the shell is very common in the Coral Rag of Brompton.

Relations and Distribution.—The very plainness of this shell is against instituting a comparison with others. The Yorkshire shell is very abundant in the Coral Rag of the Scarborough district, which includes Seamer, Ayton, and Brompton, but not at all common elsewhere. It is just possible that there may be two species of unornamented *Cerithia* in these beds.

Genus Nerinæa, Defrance, 1825.

There are few genera so difficult to arrange and describe satisfactorily as the Nerinæas of the Yorkshire Corallian beds. In some measure this is owing to the rolled and fragmentary condition of the shells and also to a sort of action which seems to have absorbed and destroyed the ornamentation. In the second edition (1835) of Phillips's Geology of Yorkshire, there is no mention of any example from the Corallian beds; and in the third edition (1875) only two species are quoted in the table at page 258.

There is great poverty in this respect in some of our museums and private collections; and yet the genus, as regards numbers of individuals, if not of species, is well represented throughout the calcareous beds of the Corallian series. Even the Lower Limestones, so poor in Gasteropoda, contain narrow, cylindrical species, having an outline similar to *N. Rœmeri;* and when we come to the Upper Limestones we find Nerinæas very numerous, especially in the Coralline Oolite, but they are difficult to extract, so as to show any character.

Much caution is required in attempting to name or describe fragments belonging to this genus; for we must bear in mind, as Buvignier has well pointed out, that the spiral angle often differs considerably in the same species. In some the exterior form undergoes modifications with age; so also it is with the form and disposition of the interior folds, which even vary in number. For this reason detached portions really belonging to the same species may receive different names, and this danger is especially to be guarded against in our beds, where entire shells, showing ornaments, are so difficult to procure. In addition to the forms which I have selected for figuring, there are one or two others which cannot be referred to any of the undermentioned species, thus raising the total number to about eight or nine.

Besides the more common narrow and cylindrical forms, there occurs in the Coral Rag of certain localities a very curious group already noticed by D'Orbigny as not uncommon in the Corallian of the East of France. This group, he observes, constitutes a sort of passage between the Nerinæas and the Actæons, having the outward form of the latter, but the internal structure of the former. The occurrence of this group in Yorkshire was first indicated by publication in the "Corallian Rocks of England."[1] It is just possible that the three species now figured and described pass into each other by various gradations.

25.—Nerinæa fusiformis, D'Orbigny, 1847. Plate XVI. Figs. 7*a*, *b*.

Nerinæa fusiformis, D'Orbigny, 1847, Prod. de Pal. Strat. vol. ii. p. 6.
Idem, 1850, Terr. Jurass. vol. ii. p. 101, pl. 257, figs. 3–5.

Bibliography, etc.—This species, originally discovered by M. Cotteau in the Department of the Yonne, is not generally quoted by continental palæontologists. It does not appear, for instance, in the very full list given by Buvignier of species found in the Coral Rag of the Meuse (*op. cit.* p. 54). Brauns does not find it in North Germany, and as he does not quote it as a synonym of the next species, we may presume that the form has not been observed. Neither this nor any of the group appear in De Loriol and Pellat's work on the Upper Jurassic rocks of Boulogne.

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

Length	66 millimètres.
Width	16 ,,
Length of last whorl to entire shell	39 : 100.
Spiral angle, average	21°.

D'Orbigny's description fits this shell so well that I cannot do better than transcribe it.

"Shell elongated, fusiform, not umbilicated. Spire formed of a convex angle composed of whorls almost flat or slightly convex, smooth, or merely marked with some lines of growth. The last whorl, which is very large, is convex in front without angles or keels. Aperture elongated, compressed; furnished with three simple folds: one on the lip, two on the columella, all scarcely marked."

Relations and Distribution.—If we may accept the silence of most palæontologists as conclusive, this particular form has, on the Continent, been noted only in the Corallian of the Yonne. A variety somewhat intermediate between this and the species next described is very abundant in the Coral Rag of Brompton (see Pl. XVI. Figs. 10 and 11), where such rolled and fragmentary specimens may often be picked up, though on the whole the Brompton shell has, perhaps, more affinities with *N. Moreana*. Casts of this or of an allied species occur at Upware in the Coral Rag.

[1] Q. J. G. S. vol. xxxiii. p. 328.

26.—NERINÆA MOREANA, D'Orbigny, 1841. Pl. XVI. Figs. 8*a*, *b*.

Nerinæa Moreana, D'Orbigny, 1841, Revue Zool. p. 319.
Idem, 1850, Terr. Jurass. vol. ii. p. 100, pl. 257, figs. 1 and 2.
Nerinæa Clymene, D'Orb., *op. cit.* p. 102, pl. 258, figs. 1 and 2.
Nerinæa Moreana, D'Orb., 1852, Buvignier, Statis. Géol. de la Meuse, p. 35.
Nerinæa tornatella, Buv., *op. cit.* pl. xxiv. figs. 10–13.

Bibliography, etc.—This fine and highly characteristic species seems early to have attracted the attention of D'Orbigny, who received specimens from many parts of the Corallian of the East of France. His figure portrays a specimen of unapproachable excellence. Buvignier's figures are more like our Yorkshire shell. His fig. 11, for instance, is very like the specimen here figured, and in his fig. 13, we at once recognize the peculiar smoothed and rolled forms so frequent in the Coral Rag of Brompton and Ruston. It is quite possible that Buvignier was justified in regarding *N. Clymene*, D'Orb., as a rolled and worn condition of the above. The name *tornatella*, given by him in 1850, would have been more satisfactory.

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

Length (restored)	92 millimètres.
Width	23 ,,
Length of last whorl to entire shell	45 : 100.
Spiral angle, average	? 25°.

Shell elongated, bottle-shaped, subturrited, umbilicated. Probable number of whorls twelve. These increase with tolerable regularity under an angle of about 25°. The posterior whorls are smooth, convex, and devoid of ornament. The two whorls posterior to the penultimate develope a varix, which in the penultimate becomes stronger. Finally, the body-whorl exhibits a large and sudden increase, which is like the reinforcement in the breach of a cannon. These last two whorls are subangular. The varices, especially the upper varix of the body-whorl, appear to have supported nodular prominences, which have been reduced by wear. Shell substance thick. Umbilicus narrow, but probably deep. Aperture greatly elongated. Outer lip curved, and only moderately compressed. The folds on the columella are well seen.

Relations and Distribution.—The most unlike a *Nerinæa* of the whole group, which seems to be in a great measure Corallian, is a shell originally described by D'Orbigny as an *Actæon*. From this extraordinary form to the more elegant *N. fusiformis* there seem to be certain gradations, of which *N. Moreana* may be taken as a sort of average, accepting Buvignier's figuring rather than D'Orbigny's for the type. In Yorkshire Sir Charles Strickland's specimen is by far the finest known to me. In the Coral Rag of Brompton and Ayton the general run of specimens is narrower, and, if possible, more bottle-shaped from the sudden reinforcement of the body-whorl. Between this variety and *Nerinæa fusiformis* there seems to be every stage, so that when the specimens are fragmentary it is difficult to come to a decision. The majority, however, show considerable traces of an umbilicus, whereas we have seen that *N. fusiformis* is not umbilicated.

Buvignier's specimens are from the Coral Rag of St. Michel, whereas Brauns quotes it as rare in his Middle Kimmeridge (Pteroceras schichten), all of which is below the Virgulian, or real Kimmeridge Clay of this country. In Yorkshire the principal localities have been already indicated. It is local, and only occurs in the Coral Rag. The group has never been noted elsewhere in England, except in the Upper Corallian at Osmington, where a specimen was found by me in 1875, which is of so singular a form as to be almost worthy of being ranked as a separate species.

27.—Nerinæa, sp. Plate XVI. Figs. 9*a*, *b*.

This peculiar form has externally but little of the aspect of a *Nerinæa*, and it is only by making a section that we obtain proofs in the absence of the aperture. The spiral angle would seem to be about 14°, and the whorls are very unequal in height. We perceive from the section (Fig. 9*b*) that the shell was thick and probably umbilicated. The disposition of the interior folds is variable. A single specimen found in the Rag Pit at Brompton (my Collection).

EXPLANATION OF PLATE XVI.

Figs. 1–3. Group allied to *Cerithium limæforme*, Rœmer.
Fig. 1*a*. *Cerithium* near to *limæforme*, Rœm. Coralline Oolite of Ness. My Collection. Natural size.
,, 1*b*. The same enlarged.
,, 1*c*. The same, whorl considerably enlarged.
,, 2*a*. *Cerithium* near to *grandineum*, Buvig. Coral Rag of Ayton. Leckenby Collection. Natural size.
,, 2*b*. The same enlarged.
,, 2*c*. The same, whorl considerably enlarged.
,, 3*a*. *Cerithium* near to *Humbertinum*, Buvig. Coral Rag of Brompton. Strickland Collection. Natural size.
,, 3*b*. The same enlarged and restored.
,, 3*c*. The same, whorl considerably enlarged.
,, 4*a*. *C. bicinctum*, sp.n. Coral Rag of the Howardians. Leckenby Collection. Natural size.
,, 4*b*. The same, two whorls enlarged.
,, 5*a*. *C. gradatum*, sp.n. Corallian of Yorkshire. York Museum. Nat size.
,, 5*b*. & *c*. Enlargements of the same.
,, 6*a*. *C. inornatum*, Buvig. Coral Rag, Seamer. Strickland Collection. Natural size.
,, 6*b*. The same, whorl enlarged to show striæ.
,, 6*c*. Another specimen (rolled), back and front.
,, 7*a*. & *b*. *Nerinæa fusiformis*, D'Orb. Corallian of Yorkshire. Leckenby Collection. Back and front.
,, 8*a*. & *b*. *N. Moreana*, D'Orb. Coral Rag of North Grimston. Strickland Collection. Back and front.
,, 9*a*. & *b*. *Nerinæa*, species or variety. Coral Rag of Brompton. My Collection. A fragment; back and front.
,, 10 & 11 Rolled specimens of *N. fusiformis* or *Moreana*. Coral Rag of Brompton. My Collection.

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

II.—Pre-Cambrian Volcanos and Glaciers.

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

The subject of the recurrence of phenomena in geological time, so prominently brought forward by Prof. Ramsay in his recent address as President of the British Association, is one which cannot fail to be of interest to the geologist, as it constantly presents itself to him in all his inquiries. There are also doubtless many who are prepared to go with Prof. Ramsay to the length of his conclusions, and who believe "that from the Laurentian epoch down to the present day, all the physical events in the history of the earth have varied neither in kind nor in intensity from those which we now have experienced;" whilst others will be inclined to believe that though generally they have resembled one another in kind, yet that some have varied greatly in their intensity. Most of the evidence, hitherto accessible to us, seems to me to favour the latter view rather than the former, especially that obtained from researches amongst the older groups of rocks. That volcanic action was more general and probably more intense in early geological time, and that glacial phenomena were less marked at that period than in more recent ones would accord, I think, best with our present state of knowledge. Volcanic action was undoubtedly prevalent during the earliest epochs of which we have any knowledge, and in former papers I have given evidence to show that it prevailed in Dimetian, Arvonian, and Pebidian times. Prof. Ramsay, however, at p. 7 of his address, says that "the oldest volcanic products" of which he had any personal knowledge are of "Lower Silurian Age."

In a paper published in the Quart. Journ. Geol. Soc. for May, 1878,[1] "On the Dimetian and Pebidian Rocks of Pembrokeshire," I stated "that a very large proportion at least of the Pebidian rocks must have had a volcanic origin. As, however, they were at first subaerial, and afterwards submarine accumulations, it is evident that they must also be partly detrital. The lowest rocks are the agglomerates, and in these I think we have clear evidence of proximity to a subaerial volcano surrounded by the ordinary materials of a volcanic cone, the largest proportion of the masses being fragments of lava which evidently had cooled under atmospheric influences." The thickness of the Pebidian group at St. Davids cannot be less than 8000 feet, and as by far the greatest proportion of the materials composing these beds, according to field, and also microscopical examination by Mr. T. Davies and others, must have had a volcanic origin, it is clear that it must have been a time of great volcanic activity. From some recent researches it is evident also that at this period in geological history, volcanic action was prevalent in many other European and American areas, probably far more so than during any subsequent period. That the metamorphism of some of the earlier Pre-Cambrian rocks was due in part to the disturbances (combined however with chemical and other influences) at this time seems also probable, and no equal effects seem to have been produced on any group of sediments since. Certainly no geologist who has paid much attention of late to the researches going on amongst the older, or Pre-Cambrian rocks, can believe with Prof. Ramsay, that the forces as at present in action are sufficient to induce equal metamorphic changes in groups of such enormous thicknesses, and over such extensive areas, as took place in Pre-Cambrian times. That during some other epochs

[1] vol. xxxiv. p. 160.

in Palæozoic, and subsequent times, metamorphism on a small scale did take place in consequence of disturbances combined with severe volcanic action no one will doubt; but the evidence is not satisfactory, to say the least of it, that any of the great groups deposited since Pre-Cambrian times have been metamorphosed under such intense influences as were then prevalent, or even have suffered more than a partial change, and that usually only over very limited areas.

Evidences showing that glacial phenomena prevailed in Pre-Cambrian times were pointed out by me in a paper in the GEOLOGICAL MAGAZINE in 1876, and there can, I think, be little doubt, that glaciers did even at that early period spread over some of the higher lands.

The Pre-Cambrian continent was doubtless studded not only with volcanic mountains, but also with high ridges and plateaux in northern latitudes, and many portions of this old continent are now visible from the latitude of 30° to the arctic regions.

It could scarcely be expected, however, that much evidence would still remain after the numerous changes that have taken place over most of the surface of this old land since it commenced to be depressed to receive the Cambrian sediments. Yet that there is some such evidence still in existence seems to me clear. The angular character of many of the masses in the Cambrian rocks which rest immediately on the old land in the Highlands of Scotland, was mentioned by me in the GEOL. MAG. 1880 (pp. 103–109; 155–166; 222–226; 266–271); and I there refer to the so-called conglomerates as more properly "breccias." I also stated that the old floor on which they rest "remains much as it was when the overlying rocks were deposited upon it." More recently Prof. Geikie[1] has called attention to the same rocks at the same place (Gaerloch), also to the condition of the old floor, and attributes, as I had previously done, in several areas, the appearances to the action of land ice. In Wales also the Cambrian conglomerates, where they rest on the old floor, contain very large angular masses, though I have never recognized blocks as large there as those in the angular breccia which is presumably of Cambrian age near Gaerloch.

In the paper in the GEOL. MAG. for 1876, p. 157, after referring to the physical features of the old Pre-Cambrian land, I stated that—"this condition of continents of great size in high latitudes, with elevated plateaux and high mountains, would lead us to believe that they were covered with ice and snow in their higher parts, and that the plains and valleys had therefore much loose material strewn over them. In the Cambrian rocks in Wales boulders of considerable size, sometimes a foot in diameter, are often found in the beds of conglomerate, and the frequent alternations of conglomerates, grits, and sandstones, seem to prove that, at least in the earlier epochs, an abundance of loose material must have been near and ready at hand to be easily denuded off as each part became submerged. Marine action on the hard metamorphic cliffs alone could scarcely have produced so much sediment. Moreover, the

[1] Nature, Aug. 26, 1880.

enormous thickness found with scarcely a trace of any beds heaped up by marine life at this period, either in the American or European areas, as may be seen by reference to the table, show conclusively that an additional force must have been at work. In some places, also, the sediments were heaped up so rapidly that during a depression of several thousand feet the rate seems only to have kept pace with the accumulations, and shoal conditions continued to prevail during the whole time." Probably glacial phenomena were restricted at this time to the higher lands in the higher latitudes, but there was nothing in the prevailing climatal conditions, certainly in later Pre-Cambrian times, to prevent the phenomena being then, as now, natural to certain elevations. The abundance of life in the Cambrian seas is sufficient evidence of this.

We have, therefore, to carry the mind into far earlier epochs ere we can expect to recognize evidences of very different conditions to those which now prevail. At present we know of no indications of life in the Pebidian, or last Pre-Cambrian epoch, but as most of the strata of that period are of volcanic origin, this is not to be much wondered at. Again there were but small marine areas in the regions now accessible to us for examination.

That glacial phenomena did prevail, therefore, at so early a period seems tolerably clear, and moreover, "That it was a cold epoch is evident from the fact that the Pre-Cambrian continents occupied very extensive areas in the higher latitudes, and that they were traversed by mountainous ranges, attaining in some cases to great heights. At no time since, unless in the Glacial Period, does there seem to have been so much land in the higher latitudes, and it is, therefore, reasonable to suppose that in the earlier stages, at least, of the epoch (Cambrian) the climate was one of extreme cold."[1]

The conclusions which I think are to be derived from the foregoing are that volcanic action has diminished probably even since Palæozoic times, and certainly since pre-Cambrian times; but that glacial phenomena have prevailed since at least later pre-Cambrian times in proportion as the geographical changes have been favourable or otherwise.

III.—The Mammoth in Siberia.

By Henry H. Howorth, F.S.A.

In a previous[2] paper we have considered some of the legends which are current among the Nomades of Siberia about the Mammoth, and which were the outcome of the curious fact that whole carcases of the animal have been discovered intact and with their soft parts and external shape preserved. This fact has not only been fruitful in romance among the inhabitants of the Tundras, and among those who are attracted by strange and unusual occurrences among more civilized people, but is in itself the key to a great deal of difficulty in understanding the later changes that have

[1] Geol. Mag. 1876, p. 252.

[2] The previous part of this paper appeared in the Geological Magazine for September, 1880, pp. 408–414.

occurred in the northern hemisphere. So interesting, and so valuable is it, that it is strange that not more has been written about it in English literature, and that most writers who have treated of the latest series of deposits have contented themselves with repeating over and over again the famous story of the Mammoth's carcase described by Adams, and have not gone further afield.

Before we consider some of the problems which are elucidated by the discovery of these carcases, we have thought that it would not be ungrateful to the readers of the GEOLOGICAL MAGAZINE to collect together such notices as may be found of the various places where and occasions on which the soft parts of the great pachyderms have been discovered, especially laying under contribution Baer's famous paper, published in the Memoirs of the St. Petersburgh Academy, which, however, was by no means a complete notice, and adding to it a more casual summary of the distribution of the bones as found separate from the soft parts in various localities in Siberia.

The existence of remains of Mammoths preserved with their flesh intact was known in Europe as early as the seventeenth century. Witsen, in his work, Noord en Oost Tartarye, edition 1694, p. 413, cites the finding of many Mammoths' teeth in Siberia, and mentions that numbers of people were engaged in searching for them. He also says that occasionally whole Mammoths were found, which were of a brownish colour, and emitted a great stench. Witsen was not alone. Isbrand Ides, who was sent as an envoy from Peter the Great to China in 1692—1695, met on his way through Siberia a man who was engaged every year in collecting fossil ivory, and who told him he had once seen the head of a Mammoth projecting from the frozen ground, which, with the help of some companions, he cut off. The inside of the head had decayed, but he secured the teeth, which he says were placed before his mouth like those of an elephant. He also took some bones out of its head, and cut off a foot of the girth of a man, of which he took a portion to Trugan (*i.e.* Turuchansk). The bones of the head were somewhat red, as if coloured with blood. Isbrand Ides knew these elephants were found imbedded in the frozen banks of the rivers, and he reports that the Russians ascribed them to the Noachian deluge, a view in which he concurred (Isbrand Ides' Travels, pp. 25, 26).

Lawrence Lange, who went as an envoy to China in 1715, after speaking of the stories of the Mammoth (which he calls the Mamant or Behemoth) living under ground, goes on to say that what convinced him most that its bones were those of a beast which still existed was that several people worthy of credit had assured him they had seen the horns (*sic*), skulls and bodies of the animal with flesh and blood still remaining, adding that if it were thought necessary it would be easy without much difficulty to collect together a perfect skeleton (Journal de Laurent Lange, in Nouveaux Memoires sur l'etat present de la Grande Russie ou Moscovie, vol. ii. pp, 110, 111).

Müller, the author of the famous collections on Russian history, who wrote in the first half of the last century, in his Memoir on the

Manners and Customs of the Ostiaks, reports how he had been told by several people that they had seen these animals beyond the Beresowa in the caverns in the high mountains of those districts. They reported them as eight or ten feet in height, and about eighteen feet long, of a grey colour, with a long head, broad forehead, and having a horn on either side just below the eyes, which they could move about, and cross one over another as they pleased. It was said that when walking they could stretch themselves considerably, and could also shrink into a small space. Their legs in size were like those of the bear. After criticizing these stories, which clearly point to their relators having seen some Mammoth carcases intact, he goes on to discuss the opinion of those who merely deemed the bones *lusus naturæ.* This he contests, on the ground that many times it had been noticed that the bones were bloody when the roots were broken, and that a cavity filled with clotted blood was often to be seen near the end (*id.* pp. 159, 160).

Laptef, who travelled along the northern coast of Siberia during the reign of the Empress Anne, 1739—1743, writes: "On the banks of several rivers on the Tundra, whole Mammoths with their tusks are dug out with thick hides on them. Their hair and bodies are however rotten, while the bones, except the tusks, are also decaying." He describes the heads of the animals as like those of a Horse, while their teeth were thick, flat, and not longer than three inches, a description which made Middendorf suppose he had seen the heads of the fossil Rhinoceros, which are like those of a Horse. It is probable he confused the two animals, of which he had heard or seen specimens.

The next notice we have of the finding of one of these preserved animals refers to the *Rhinoceros tichorhinus,* and not the Mammoth. A head and foot of the Rhinoceros were taken to Pallas, when he was at Irkutsk in 1772. The complete animal had been found in the preceding December at Wiljui, about 64 versts below Yakutsk, and it had then begun to putrefy. The head and three feet were sent to Irkutsk, and the fourth foot to Yakutsk. One of the feet was destroyed by being dried too quickly; the other remains were described in a famous memoir by Pallas, and later by Brandt. They are still to be seen in the Zoological Museum at Petersburgh. Pallas did not himself visit the site where the body was found, but was told by the person who had sent him the remains that the carcase was half buried in the sand a fathom from the water of the river, and four fathoms from a high steep bank. It was covered with a thick hide, over which were some scattered tufts of hair. The beast had clearly not been long where it was found, and had probably been detached from the bank in the spring floods of the years 1769 or 1770, and the sand in which it was found buried was probably a portion of the matrix which surrounded him in his grave. (Pallas, de reliquiis animalium per Asiam borealem, etc., Nov. Comm. St. Peter. Acad. vol. xvii. p. 576).

In 1787, Sarytschef, who accompanied Billing in his well-known journey through Siberia, was sent in company with Dr. Merk and others from Sredne Kolymsk to Yakutsk. At Alaseisk, a small station on the river Alaseya, about 100 versts down the river, and in its sandy banks, he was told there was the body of an animal of the size of an elephant. It was still whole and covered with its hide, and here and there had long hair on it. Sarytschef unfortunately did not visit the spot, which was a good deal out of his way.

About the same time, or even earlier, a Mammoth covered with hair was found at the mouth of the Lena, for when Adams' specimen was discovered, the Tungus told him that their fathers had told them that one of their number had seen a similar animal, and had then immediately died with all his family. The new discovery he deemed an evil omen, and fell ill.

In 1805, when Tilesius was on his way to Kamstkatka with Krusenstern's expedition, he was told by Patapof, who was carrying provisions from Okhotsk, that he had a short time before seen a Mammoth with a hairy skin, on the shore of the Polar Sea, and as evidence he sent Tilesius a bunch of its hair, which he in turn sent on to Blumenbach. Adams speaks of another similar find two years before his own discovery on the banks of the Lena a long way from the sea.

We now arrive at the famous Mammoth with which the name of Adams is so associated. Adams was a botanist, who was at Yakutsk in 1806, when he heard that a Mammoth with its flesh, skin, and hair intact, had been found on a peninsula at the mouth of the Lena. On going there he learnt that a Tungus chief named Ossip Schumakhof, in a journey to the borders of the peninsula of Tamut in 1799, saw a hummock or lumpy hill. In 1801 this had melted away partially and disclosed the side of a large animal with a tusk projecting out. The following summer proved a very cold one and the animal melted very little. In 1803, the ice between it and the cliff melted, and it subsided on to a bank of sand lower down. In March, 1804, Schumakhof returned to the Mammoth, detached its tusks, and bartered them for goods of the value of 50 roubles. The Tungus drew a picture of the animal, which Adams said was very incorrect. It had pointed ears, very small eyes, feet like a Horse, and a line of bristles along the back, and looked like a cross between a Pig and an Elephant. The merchant Boltunof, who saw the carcase in 1803, before it had decayed, mentions that it had a long snout between its tusks (*i.e.* a trunk). Adams did not see it till 1806. In the meantime the dogs of the Yakuts and the wild animals had eaten its flesh, and Adams found little more than the skeleton, of which one of the fore-limbs was lost. The bones were still united by thin ligaments, the skin on the head was dried up, and a bunch of hair remained on one ear. In the left eye he thought he could distinguish the pupil.

The skin of the side on which the animal had lain was still covered with thick hair. Adams secured a portion of this hide, which was so heavy that ten men with difficulty dragged it on to the bank. He also collected a pood of long hair, which lay scattered about the ground round about. These remains are still in the Zoological

Museum at Saint Petersburgh. When Adams found the remains, they were about 100 paces from the steep bank from which they had slid down. This bank was from 35 to 40 fathoms high, and the Tunguses reported that they lay at first under seven fathoms from the surface. Adams reported that the remains were found imbedded in a stratum of clear ice.

The delta of the Lena has undergone considerable alterations, but the site of the discovery may still be made out. It is on an island marked as a peninsula in Wrangell's map, but which is now an island, as appears from the staff survey map of the Russian government issued in 1855. It lies in the Polar Sea opposite the little station of Kumak Surka on the Lena. Its northern point is called Myss Bykofskoi, and its southern one Myss Mostach (the Manstai of Adams).

During Schrenck's journey across the Samoyede steppe in 1837, he heard of the discovery of two skeletons of pachyderms in the great peninsula of Karakhaiskaya which separates the Kara Sea from the Gulf of Obi. One of them was found on the left bank of the river Yerumbei or Yerubei, four or five years before Schrenck passed that way. It was described to him as being as big as a walrus, but without tusks. Schrenck suggests that it was the skeleton of a rhinoceros, but it may be that the tusks had been previously broken off and carried away. It had apparently lain exposed a considerable time, and the bones were of a brown colour. Another skeleton not quite so perfect had been found ten years before on the same peninsula, and was well known to the Samoyedes (Baer, Bull. Sc. St. Peters. Acad. vol. x. *op. cit.* 278–279).

In 1840, an entomologist named Motschulsky was at Tobolsk, where he was told by the Samoyedes that the spring of the previous year had been very wet. This had washed away a portion of the bank of the river Tas, a tributary of the Yenissei, and exposed the body of a frozen Mammoth. They had seen its head and one of its tusks, the latter of which they had detached and sold at Obdorsk. They reported that from the jaws of the animal there projected a tongue as long as that of a one year old reindeer, by which they no doubt meant the trunk of the animal. Some difficulty has arisen about the exact locality of this Mammoth, as no such river as the Tas falls into the Yenissei, and Baer suggests that the Samoyedes may call the wide outlet of the latter river by that name. At all events, a merchant of Berezof, named Trofimof, undertook to bring the remains to Obdorsk, which he did, and they were found by him not far from the Yenissei, about 70 versts from its outfall into the sea near a cliff. This skeleton was removed to Moscow, and still remains in the museum there. Portions of hair and of the flesh still remained on it, upon which Professor Glebof has written.

In 1843, Middendorf found the remains of a Mammoth near the river Taimyr, only 50 versts from the Polar Sea, in about 75° N.L. He describes the animal as but half grown. Its flesh had nearly decayed away, and the bones were soaked through from the great moisture of the clay in which they lay. They still retained their form however, and it was clear the flesh had decayed away on the spot, from there being found there two inches thick of a dark brown mud, which surrounded the bones, which had a strong ammoniacal smell, and was clearly a decayed animal substance. The banks of the river were about six fathoms high, and consisted of coarse sand containing boulders of various kinds of stone from the size of a nut to that of a man's head. Some of these boulders were taken home by Middendorf and were classed by Keyserling as granite, white felspar, gneiss containing garnets, black mica slate, and a peculiar breccia formed of pieces of anthracite welded together by white carbonate of lime. Half-way up the cliff in the otherwise unstratified sand, was a layer an inch thick of fine-grained peat mixed with coarser sand. Higher up, and five to seven feet below the surface, lay the remains of the Mammoth in a layer of sand mixed with clay. The boulders did not apparently reach so high. The animal lay on its left side (Baer, *op. cit.* 285).

A Mammoth was found some time between 1840 and 1850 in the circle of Yakutsk. It was mentioned in a notice by Herr Schtschukin, who had lived long in Yakutsk, and was afterwards in correspondence with the place. It was probably the same animal of which a foot is preserved at Irkutsk, and was mentioned by Schrenck. It was well preserved when found, and the animal had a mane of long hair reaching from the neck to the tail. Like most of the others it was found in the bank of the river, which had been undermined by floods. The Archbishop of Yaroslaf reported that the animal had been found by a missionary named Khitrof, who reported that it had a shaggy mane, and that its head was covered with hair; remains of its food between its teeth consisted of twigs of trees (Bull. St. Pet. Acad. vol. x. pp. 118, 362). It seems this Mammoth was found on the banks of the Kolyma (*id.* 362).

Baer was told by the doctor, Alexander Golubef, who had practised long in Yakutsk, that about 1860 or 1862 the Yakuts had found a huge beast covered with skin on the banks of the Wiljui, where it falls into the Lena, which they reported to the Yakutsk merchant, Ivan Platonovitch Kolessof.

A Yurak, who was looking for his reindeer on the Tundra, near the bay of Tas, noticed projecting from the ground a horn (so they call the Mammoths' tusks found in Siberia). In order to secure this he scraped away as much as he could of the earth, and disclosed the head of a great beast. Having drawn or broken off the tooth, he detached also a portion of the hide as evidence, which he gave to the village elder of Dudinsk, Athanasius Koschkarof, who passed it on to the overseer, Sotnikof, who showed it to Ivan Maksimof, an engineer on one of the steamers on the Yenissei, who again communicated the important news to M. Stephen Gulayef, and he to the Russian naturalist, K. E. von Baer. The news was communicated in a letter from Karl Maximovitch to Stephen Gulayef, dated Barnaul, 30th November, 1865 (Bull. St. Pet. Acad. x. 230–234).

On the receipt of this news, the Imperial Academy nominated a Commission, consisting of the well-known names of Brandt, Helmersen, Schrenck, and Baer (*id.* 239), and it was determined to send an expedition to recover, if possible, the skeleton and other remains of the Mammoth, and to take a plaster cast of his shape. This expedition was put under the command of F. Schmidt, who was ordered to set out in February, 1866. When he arrived in Siberia, he found that the carcase he was in search of had decayed. Kaschkaref had visited the place in the spring of 1865, and found some bones and a piece of decayed hide only (*id.* 513). The place where the remains were found was on the Yambu, a small lake from which springs the river Gyda (*id.* 521), about 100 versts to the north-west of Maksimof Myss. The tundra about there is quite naked, alder bushes and grass grow apparently near the rivers. Schmidt describes the land of the Yuraks as a veritable mine of Mammoths' remains, and affirms his belief that the specimen in the Moscow Museum came from there, from the Simovie Krestowskaya close to the Polar Sea. Schmidt heard of another skeleton of a Mammoth with hair still remaining on its head, which lay on the Awamskian tundra, and exposed to the air (*id.* 516). He eventually secured a number of the bones, and a quantity of the hair of the former specimen (*id.* xi. 80–90).

In the summer of 1867 another Mammoth, with its flesh and hide intact, was found about 100 versts from the Polar Sea, between the rivers Indigirka and Alaseya, and on a small river called Kovschetschaja, whose mouth is about 50 or 60 versts from that of the Alaseya. It was found by a Tungus named Foka, who spent the summer there in search of Mammoth bones. Its flesh, it was reported, had been eaten by wild animals. This discovery was very important, from the place where it was made, which was about the same meridian as New Siberia; it was one and a half day's journey north of the limit of trees, and about five days' journey from the Polar Sea. Schrenck says that the Mammoth's body referred to by Sarytschef as having been found in 1787 was found on the Alaseya; while Kosmin, a companion of Wrangell, who made a journey in 1821 along the Polar Sea from the Kolyma to the Indigirka, passed the River Uschiwaja, called Pila by the Jukagirs, which is about half-way between those two rivers, found a collection of Mammoths' bones which had been washed out of the banks by the undermining of the river (Bull. St. Pet. Acad. vol. xvi. p. 153).

A Yakut, who was sent by the Baron Von Maydell to find the remains of this Mammoth, found only a leg, with one end sticking in the ground, but without flesh or hide, covered with skin only on the hoof; he also found a piece of the hide with hair still on it the size of half a horse's skin.

Meanwhile news arrived at Nishni Kolymsk of the discovery of another Mammoth's body. Of this but the skeleton remained; it lay some fathoms from the right bank of the River Kolyma, 200 versts above Nishni Kolymsk, out on the open ground (*id.* 155 and 156).

Maydell noted the spot where the first of the three Mammoths had been discovered, but when he went he found only a number of Mammoths' bones. On his way to it he heard of a third find. A Yakut told him that on a stream not far from the Kovschetschaja, where a former Mammoth had been found, he had seen the leg of a great beast, with flesh and hide upon it, sticking out of the ground. This was in the summer of 1870. This he had detached by moving it backwards and forwards. The site of this find was on the tundra between the Indigirka and the Alaseya, which is very prolific in Mammoths' remains, so that a number of men are annually engaged in searching for ivory there. It is watered by a number of small rivers, the most eastern of which is the Kovschetschaja, where the second of the above-named Mammoths was found. Forty versts west of this was another river named the Schandran, where the third Mammoth was found. Maydell visited both places. In the first he found a number of bones, and a piece of the hide four arshins long and one and a half broad, covered in places with yellowish short hair, and longer hair of a brown-red colour. He then went on to the second site, where he recovered the leg which had been detached the year before by the Yakut. It was broken off at the knee, and, according to Maydell, seemed to have been detached long before, as the exposed parts of the bones seemed weathered, and of a brown colour. There was no flesh remaining, but the hide was intact, and ended in a rounded foot with a horny sole. He succeeded in finding another similar limb, and a mass of earth mixed with Mammoth hair, but nothing more; the rest of the animal had been dispersed either by being dragged away by wild animals, or by being broken and washed away by the water or otherwise.

This completes our view of the distribution of the remains of Mammoths in Siberia which still retain their soft parts, and it will be noted that they have occurred in various and widely separated meridians, from the eastern water-shed of the Obi to the peninsula of the Chukchi, and they have been found naturally where the climate is the most severe, and where the tundra is the most bare of vegetation. The list of places where bones and other remains of these pachyderms have occurred is such an extensive one, that I shall not attempt to give a complete index to it, but only collect a series of localities to prove how wide-spread the remains are.

When the Russian envoys went to Japan from Petropauloski, in Kamskatka, one of them, named Kusholof, brought home some tusks and fragments of Mammoths' bones which he had found in the latter peninsula (Tilesius, *op. cit.* 423). Wrangell found a tusk in a small brook near the River Aniuj (*op. cit.* 307), and he says both Mammoth and Rhinoceros remains are found in the Little Aniuj. Several Mammoth bones and pieces of Whalebone were found on the tundra west of the Baranicha (*op. cit.* 286). These bones, he says, are found in hills surrounding the lakes near the Baranof rocks (*id.* 283), and he records a Mammoth's jawbone from the Great Aniuj. He says that between the Kolyma and the Indigirka there is a long perpendicular ice-cliff, which never thaws, and in which the ice is mixed with a little black earth and clay, and where the waves have washed away the earth, Mammoths' bones not unfrequently appear, and he again adds that the whole of the coast from the Aleseya to the Indigirka is rich in Mammoth bones. While near the Baranicha, between a low hill and the sea, the ground might be said to consist entirely of Mammoth and Buffalo bones. He noticed a large heap of jawbones that had been thrown aside by a previous party. In regard to the Bear Islands, he says: The soil of the first Bear Island consists only of sand and ice, with such quantities of Mammoth bones that they seem to form the chief substance of the island. Among the bones are also found the skulls and horns of an animal resembling the Buffalo (*i.e.* of the Bison).

The people on the Indigirka are employed in trapping foxes and collecting Mammoth bones. Near the mouth of the Uschewaya the banks are often undermined, and Mammoths' bones exposed, of which the Yukagiri obtain a large supply annually. This part of the coast is generally rich, he says, in Mammoths' bones.

Further west Erdmann tells us that in the lower valley of the Lena, at the place where the Vilui disembogues into that river, between the rocky hills which confine the course of the Yana, and at the Icy sea on both sides of the mouth of the river, are found the teeth and bones of Mammoths, Rhinoceroses, and other quadrupeds, and even whole carcases (*op. cit.* vol. ii. p. 378).

But the most famous deposits of all of the Mammoth bones are found in the Liachof archipelago, so called from a merchant named Liachof, who in the year 1770 began to collect fossil ivory there, and so enriched himself that he got the exclusive privilege of digging for the ivory there, a privilege which he transmitted to his descendants. These famous islands are situated off the promontory known as Sviatoi noass, between the mouths of the Yana and the Indigirka, and about 74° N.L.

According to the report of Samukof, who was there frequently, the soil of the first of these islands is almost composed of fossil bones, and near it is a mud bank which exposes fresh ones with every storm. This made him conclude that a large deposit lay under the sea there.

In one of these islands is a lake with high banks, which split open in the summer, when the sun melts the ice, and disclose heaps of tusks, Mammoths' bones, and bones of Rhinoceroses and Buffaloes (doubtless Musk Oxen are meant). The ivory is often as fresh and white as that from Africa. In other parts of the island bones and tusks are to be seen projecting from the ground. Liachof was engaged for many years in digging ivory there, and built huts and a magazine for his people who lived there in the summer. North of the Liachof Islands are those known as New Siberia. These consist of the islands known as Kotelnoi, Fadeyefskoi, and a third more to the east. They were partially discovered by Liachof's people, who, however, kept the matter secret. Another speculator obtained a special privilege of digging there. Later, Count Rumanzof, Herr Hedenstrom, with a number of companions, among whom was Samukof, went there. Hedenstrom reports that in the most eastern of these islands he had found ten Mammoths' tusks standing out of the ground in the space of a verst. Hedenstrom and Samukof report these islands, especially Kotelnoi, as abounding in heads of Sheep, Cattle, and Horses. The place has unfortunately not been visited by a naturalist, so that it is impossible to say whether these Sheeps' heads belong to the Siberian Mountain Sheep, *Ovis nivicola*, or to the Musk Ox, and whether the so-called Horses' skulls may not be those of Rhinoceroses. There are also large heaps of wood lying so thickly that the Russians call them wood hills. So plentiful are the Elephant remains, that in 1821 an ivory merchant from Irkutsk collected 20,000 pounds of elephant ivory from the islands of New Siberia. Samukof himself, in 1805, collected 250 poods, or 10,000 pounds, of this ivory, and the trade goes on regularly (Baer, *op. cit.* pp. 253, 254).

The same report as to the abundance of these remains comes from other parts of the northern coast of Siberia.

The branches of the two rivers Aniuj, tributaries of the Kolyma, are, according to Maljuschkin, rich in fossil bones. The bones of the carcase, other than the tusks, when they still retain a quantity of fatty matter, are used for fuel or for other domestic purposes. The supply of fossil ivory drawn from northern Siberia during the last two centuries must have been enormous, and still gives no signs of waning. From 1825 to 1831 there was never, according to Middendorf, less than 1500 poods of fossil ivory sold at Yakutsk; one year it reached 2000 poods. From 80 to 100 at Turukhansk, and 75 to 100 at Obdorsk. The number of individual Mammoths deposited may be guessed from the fact that many of these northern tusks are small, and weigh only about three poods, or 150 pounds each.

West of the Lena the Mammoth occurs also in great quantities. Middendorf found its remains on the Taimyr peninsula. Gmelin found those of a Rhinoceros on the new Tunguska.

Pallas and others have reported Mammoths' remains as found in the valleys of the Yenissei, the Angara, the Chalaiya, the Irtish, the Tom, the Tobol, the Ob, the Alei, in the country of the Barabinski, the banks of the Volga, and the Ural, etc. They are, in fact, found distributed all over Siberia from the Ural Mountains to the Pacific. They are not, however, distributed equally over Siberia, but, as Wrangell says, form immense local accumulations, which become both richer and more extensive the further one advances to the north, being found in the greatest abundance in the islands of the Leachof archipelago, more sparingly on the main land, and but rarely in Southern Siberia (Wrangell, 185, note).

The presence of the remains of these vast animals in such abundance in a country so sterile, and so given up to the hardest conditions of climate, etc., where there is now in winter the barest sustenance for the raven and the snowy owl, and they alone, has ever been a subject of marvel and surprise, has given rise to many theories and many opinions. These are well worth sifting more closely than they have hitherto been, for they involve answers to riddles nearer home than Siberia. We will postpone a survey of them to another communication.

The following Errata refer to the previous article by me in the GEOL. MAG. Sept. 1880, p. 408.

Page 409 *line* 25 *for* Nurnan *read* Russian.
,, ,, ,, 46 ,, p. 387 ,, vol. ii. p. 387.
,, 411 ,, 11 ,, Dudmo ,, Dudins.
,, ,, ,, 42 ,, Kiachtu ,, Kiachta.
,, ,, ,, 46 ,, Tutungian *read* Tai-tun-gian.
,, 412 ,, 2 ,, Bun zoo gan rom *read* Bun-zoo-gan-mu.
,, ,, ,, 24 ,, Observationes *read* Observatio.
,, 413, last line, *for* days *read* months.

IV.—ON THE CARBONIFEROUS POLYZOA.[1]

By G. R. VINE, ESQ.

AS so much remains to be done before the Palæozoic Polyzoa can be properly classified—more particularly the Carboniferous species—it seems to me that the wisest course to adopt is to go carefully over the work of other authors, reviewing their labours generally, and giving, in as condensed a form as possible, the results of their varied efforts.

David Ure,[2] the son of a working weaver in Glasgow, is the first, so far as I am aware, who drew attention by figures to British Carboniferous Polyzoa; and Martin[3] gives some good figures of Zoophyta, but species of these belong to both the Corals and Polyzoa. Thirty-five years after the publication of Ure's work, Dr. Fleming[4] named some of the species figured, and the Zoophyta he called *Cellepora Urii* and *Retepora elongata.* The first of these, according to Mr. Robert Etheridge, Jun.,[5] is *Chætetes tumidus*, Phillips, and the other is a *Fenestella.*

In 1826, the work of August Goldfuss[6] was published. In this a system of nomenclature was adopted, and many figures of Polyzoa and Corals given, which to a large extent assisted investigators and helped them to identify species found in this country. The generic terms used by Goldfuss were accepted by authors who followed him, but as no distinction was made by the earlier investigator in separating true Polyzoa from true Corals, those who worked from his types and descriptions fell into his error, and mingled, for a time, Corals and Polyzoa together whenever they had fresh forms to describe.

The chief of the generic terms used by Goldfuss were :—

1. *Gorgonia*, Linnæus, 1745.
2. *Cellepora*, Gmelin, 1788?
3. *Retepora*, Lamarck, 1816.
4. *Ceriopora*, Goldfuss, 1826.

The type of Linnæus' *Gorgonia* was altogether different from the

[1] British Association—Section C. (Geology).—Report of the Committee, consisting of Prof. P. M. Duncan and Mr. G. R. Vine, appointed for the purpose of reporting on the Carboniferous Polyzoa. Drawn up by Mr. Vine, Secretary.
[2] History of Rutherglen and East Kilbride, 1793.
[3] Petrefactions of Derbyshire, 1809, *Petrefacta Derbiensia.*
[4] History of British Animals, 1828.
[5] Ann. Mag. Nat. Hist. 1874.
[6] *Petrefacta Germaniæ.*

types of Goldfuss's genus. The first had reference to the fixed Polypiferous masses which are still known by the same name, but the last are now referred to the *Fenestellidæ*.

The species of *Cellepora* are now placed with *Chætetes*, and most, if not all, of the *Ceriopora* of the Palæozoic era are also referred to *Chætetes* and to *Alveolites*.

The use of the term *Retepora*, as applied to Palæozoic forms, has been abandoned, and the better defined generic term *Fenestella* used instead; but Lonsdale,[1] in his otherwise clearly defined characters of this genus, included both *Fenestella* and *Polypora* types in the one description of the genus.

However we may differ, at the present time, from Professor Phillips[2] in his arrangement of the 'Zoophyta' found in the Carboniferous rocks of Yorkshire, we must give him the credit for being amongst the first to attempt a division between Corals and Polyzoa; but in the use of Lamarck's genus *Millepora* for some of his species, he seems to have been very undecided as to the true character of his fossils.

Phillips describes eight species of *Retepora*, defining certain terms which he uses, such as fenestrule, dissepiments, and interstices —terms still used in later descriptions of *Fenestella*. His species were *R. membrancea, flabellata, tenuifila undulata, irregularis, polyporata, nodulosa*, and *laxa*. The poverty of Phillips's diagnosis renders identification of his species a very difficult matter, but some of his species were so truly typical in their general, as well as in their minute characters, as to enable Mr. G. W. Shrubsole, in his elaborate review of the *Fenestellidæ*,[3] to retain three of them as types of his very restricted Carboniferous forms. The retained species are:—

Fenestella membranacea, syn. *F. tenuifila*, Phill., and *F. flabellata*, Phill.
,, *nodulosa*, Phill.
,, *polyporata* ,,

The *Retepora flustriformis*, Phill., has been placed as a synonym of *F. plebeia*, M'Coy, by Mr. Shrubsole,[4] and as *Ptylopora* by Morris.[5] By Phillips it was regarded as the *Millepora flustriformis*[6] of Martin, and he also said it resembled the *Gorgonia antiqua* of Goldfuss. *Retepora pluma*, Phill., is now *Glauconome*; and *Flustra? parallela*, which Phillips describes as "Linear: longitudinally and deeply furrowed, cells in the furrows, in quincunx, their apertures oval, prominent"[7]:—M'Coy[8] refers to the genus *Vincularia*, Defrance, and Morris[9] places it and another species of M'Coy's with the genus *Sulcoretepora*, D'Orb. The species has no affinities with any of these genera, it appears to me to be the Carboniferous descendant of the more ancient *Ptilodictya*, Lonsd. (= *Stictopora*, Hall). The non-celluliferous, striated, sometimes rugose margin, and the central laminar axis or septum, which divides the cells of opposite sides,

[1] Geology of Russia.
[2] Geology of Yorkshire, 1836.
[3] Quarterly Journ. Geol. Soc. 1879.
[4] Ibid. p. 278.
[5] Catalogue of British Fossils.
[6] *Petrefac. Derbiensia.*
[7] Geology of Yorkshire.
[8] Syn. Carb. Foss. of Ireland.
[9] Catalogue of British Fossils.

are almost always present in the Carboniferous species. I therefore, prefer to leave the *Flustra?* which Phillips describes with *Ptilodictya* as *P. parallela*, Phill., and this reference is founded upon original investigation of various specimens of *Ptilodictya*, of the American Silurian species,[1] *Ptilodictya Meeki*, Nicholson, Devonian species,[2] as well as all the known species of *Sulcoretepora* of the Carboniferous Limestone series.

The *Millepora* of Lamarck seems to have been the generic type of both Goldfuss and Phillips, and in describing the Carboniferous species, the latter author adopted the class Polypiaria of the Radiate Division of the Animal Kingdom at that time current among naturalists. It was Phillips's misfortune, rather than his fault, that he had to follow in his classification the authority of those who preceded him. Of the six species of *Millepora* described, four are easily identified—the other two are not so easily recognized.

Millepora rhombifera, Phill., Geol. of Yorkshire.
,, *interporosa* ,, ,, ,,
,, *spicularis* ,, ,, ,,
,, *oculata* ,, ,, ,,
,, *gracilis* ,, Palæozoic Foss. of Devon, etc.
,, *similis* ,, ,, ,, ,, Torquay.
,, *verrucosa*, Goldfuss. Of this Phillips says, "a species like this appears at Florence Court, Ireland." [3]

No group of Polyzoa, recent or fossil,[4] has caused so much trouble to palæontologists as the little group here tabulated from Phillips. Members of it have been referred to no fewer than five distinct genera, and even now they may be safely referred to three, if not to four. Rather than postpone the analysis of the species, I shall prefer to draw upon later work, and do it here instead of elsewhere.

Millepora gracilis is referred to by Phillips in his later work,[5] for he seems not to have noticed it in the limestone, Yoredale limestone, or shales of Yorkshire; yet it is most common everywhere, whilst the *M. rhombifera* is by far the rarer species. We have the authority of Phillips himself, that the species I am dealing with were his; for in a letter which he addressed to Prof. J. Young, and Mr. J. Young, of Glasgow,[6] he says, "I agree with you in referring your beautiful specimens to the three species (*M. gracilis, M. rhombifera*, and *M. interporosa*) named in my books ("Yorkshire," vol. ii. and "Palæozoic Foss."). Your examples are better than mine were; but I have no doubt of the reference, etc." Morris places the whole of Phillips's species—with the exception of *M. spicularis* and *M. oculata*—with the *Ceriopora*;[7] the exceptions, for what reason I cannot explain, he places with the *Pustulopora* of Blainville, a genus that had no existence in the Palæozoic seas.

[1] Niagara Group: Hall, Palæontol. of New York, vol. ii.; Nat. Hist. New York, part 4.
[2] Geol. Mag., 1875, pp. 19-20, Pl. 6, Fig. 14.
[3] Geol. of Yorkshire.
[4] Excepting *Lepralia*.
[5] Palæozoic Foss. of Cornwall, Devon, etc., 1841.
[6] April 3, 1874; Ann. Mag. of Nat. Hist., May, 1875.
[7] Catalogue of British Fossils, 1854.

Millepora rhombifera, Phill., Geol. Yorkshire.
„ *gracilis* „ Palæozoic Foss.

Both *Ceriopora*, Morris, Catalogue.

Rhabdomeson gracile and *R. rhombiferum*, Young and Young.

Gen. Ch.—R. gracile. "Stem slender, cylindrical, branching at right angles to the stem never less than an inch apart; and consists of a hollow axis formed by a thin calcareous tube, and of a series of cells ranged round the axis . . . apertures of cells, oval . . . ridges tuberculated."[1]

R. rhombiferum. "Stem slender, cylindrical, free; branches of nearly equal diameter given off at wide intervals . . . cells in quincunx all round the stem; surrounded by tuberculated ridges . . . cell-area more numerous on one face than on the other . . . central axis slender, slightly flexuous, and without transverse septa."[2]

For these two species, the Messrs. Young of Glasgow have founded a new genus—*Rhabdomeson*—on account of the peculiar central hollow axis which they possess, and on which the cells are arranged. This peculiarity is unique—for I know of no other Polyzoon having a rod or mesial axis similar to these. Some of the *Graptoloidea*, sub-order *Rhabdophora*, Allman, possess a mesial axis, and so do the *Rhabdopleura*, class Polyzoa, order *Phylactolemata*; but whether we should be justified in assuming on this account either Hydroid or Phylactolematous affinities for these fossils is a very serious question to decide. The assumption in either case would involve the discussion of many problems into which I cannot enter here. The Messrs. Young, in the two papers referred to, have gone into the question very fairly, and those who follow them in their critical remarks must remember that they are contending for the antiquity of a type of Polyzoa organization not—previous to their discoveries—known to exist in a fossil state. I have carefully followed the authors in all their investigations of this intricate question, but I am not prepared to use this fossil type as in any way indicative of the existence of *Phylactolematous* Polyzoa in Carboniferous times. At the same time it would be mere carping on my part to ignore its existence as indicative of peculiar structural characters that may help us in our future classification of the Palæozoic Polyzoa.

Millepora interporosa, Phill., Geol. of Yorkshire.
Ceriopora interporosa, Morris' Catalogue of Brit. Foss.
Vincularia Binniei, Etheridge, jun.[3]

This species is a very variable one. Phillips speaks of it as having "oval pores," whilst the *Millepora similis* has more elongated pores; on the other hand, *Vincularia Binniei* is spoken of as having "oval to hexagonal cells arranged in quincunx; or in oblique ascending lines." The magnified figure of a series of cells given by Mr. Etheridge as an illustration of his species, is one of the rarer

[1] Messrs. Young, Ann. Mag. Nat. Hist., May, 1874.
[2] Ibid. 1875.
[3] Geol. Mag., April, 1876.

varieties of *M. interporosa*. Had Mr. Etheridge contended for the variety, I should not have disputed his claim, but as he introduces a most anomalous genus into the classification of our Carboniferous Polyzoa, I cannot do otherwise than point out the anomaly. Defrance's genus *Vincularia* had no existence whatever in Palæozoic times. D'Eichwald, on whose authority Mr. Etheridge rests, is most unreliable on this point.[1]

It is on account of their importance that I have dwelt so fully upon these species. They had a wide geographical range in Carboniferous times, and though their variability is great, they have many structural characters in common with the *Ceriopora* which range into the Mesozoic and Tertiary strata.

Under the auspices of Sir Richard Griffith, Bart., Frederick M'Coy published his "Synopsis."[2] There is ample evidence in this work that M'Coy had much better material than Phillips, and his drawings and diagnosis of species are more elaborate. M'Coy adds no fewer than twelve species of *Fenestella* to our British Polyzoa. They are *F. plebeia, carinata, formosa, crassa, multiporata, ejuncida, frutex, hemispherica, Morrisii, oculata, quadri-decimalis*, and *varicosa*. As I shall have to speak of these farther on, I will leave the list without any further comment.

M'Coy retains a few puzzling forms under the name of *Gorgonia*. These are *G. assimilis*, Lonsd.; *G. Lonsdaliana*, M'Coy; and *G. zic-zac*, M'Coy.

Another fenestrate genus, introduced by M'Coy, bears the name of *Ptylopora*. There is a feather-like arrangement in this genus; a central stem giving off lateral branches which are connected by dissepiments having oval fenestrules. *Fenestella* owes its expansion to the bifurcation of its branches. *Ptylopora* very rarely bifurcates, there is a basal extension of the polyzoary along the central stem. One species is recorded by M'Coy—*P. pluma*—but it is a genus that deserves to be more closely studied than it has been. In naming some fossils lately for Mr. John Aitken, F.G.S., from the neighbourhood of Castleton, Derbyshire, I detected several small fragments of this beautiful genus. The broad central stem, whenever fenestration was absent, might easily be mistaken for a robust *Glauconome*.

The *Glauconome* which M'Coy figures and gives descriptions of are, *G. grandis, G. gracilis*, and by his discoveries he extends the range of Phillips's *G. bipinnata*.[3]

Vincularia I have already repudiated, and the *V. parallela*, Phill., which M'Coy accepts as a type, I have alluded to when describing Phillips's species. The *Berenicea megastoma*, M'Coy=*Diastopora*, Mor. Cat., will be placed in the genus *Ceramopora*, on account of its many well-marked characters.[4]

Having all the material at hand for the work, I shall now discuss

[1] See paper on *Vincularidæ*, mihi. Read before the Geol. Soc. June 23, 1880.
[2] Synopsis of the Carb. Foss. of Ireland, 1844.
[3] Upper Devonian, Croyde, Pilton, Devon, Phill., Palæozoic Foss.
[4] See paper on *Diastoporidæ*, mihi; read before the Geol. Soc. May, 1880.

the relative value of the genera and species introduced by various authors since the publication of the volumes alluded to.

Synocladia, King, 1849.

1873. *Synocladia biserialis*, Swal., var. *carbonaria*, Etheridge.
1878. *Synocladia ? scotica*, Young and Young.[1]

The type of this genus is very peculiar, and as it is well illustrated in King's Permian Fossils, once seen it can hardly ever be forgotten. "The corallum is cup-shaped, with a small central root-like base: reticulated, composed of rounded narrow, often branched interstices, bearing on the inner face from *three to five alternating* longitudinal rows of prominent edged *pores*, separated by narrow keels, studded with *small irregular vesicles* alternating with the cell pores." The essential characters of this genus I have put in italics.

In the "Ann. and Mag. of Nat. Hist.,"[2] Mr. Robert Etheridge, jun., described a "peculiar polyzoon from the Lower Limestone Series of Gilmerton, under the name of *Synocladia carbonaria*." An almost identical form had been previously referred, by Mr. Meek,[3] to *Synocladia biserialis*, Swallow.[4] After very minute investigations, kindly supplied to him by Mr. King, Mr. Etheridge says, "I have ascertained that our Scotch fossil agrees so closely in its main characters" with the American species, "that it can be only regarded as a variety of it."[5]

To *Synocladia biserialis* Mr. Meek also refers *Septopora cestriensis*, Prout, "a form which appears to differ only from the typical species of *Synocladia* by having from one to four rows of cell-apertures on the dissepiment instead of two."[6]

In 1878, Prof. Young and Mr. John Young published[7] details of another *Synocladia*, which they called *Synocladia* (?) *scotica*, from the Upper Limestone Shales, Gillfoot and Garple Burn, stating that "in both localities it is very rare." If we accept the departure from the original type of *Synocladia*, which I have no objection to, seeing that Prof. King uses the term for Palæozoic Polyzoa alone, then these two species of the genus may be recorded as existing in Carboniferous times. They have the "small irregular vesicles alternating with the pores," not unique with this genus, for several others contain a "secondary pore." Having examined this secondary pore in thin sections of Carboniferous species, I can only account for its presence as being indicative of the existence of a vibracula in these ancient types. There are, however, most essentially definite characters in the Carboniferous *Synocladia* yet to be accounted for. Very frequently, in even the smallest fragments, pores, similar to the secondary pores on the face, are constantly found on the reverse also. I know of no analogy in more recent fossil or living species to which I can refer to account for this feature in this ancient type.

[1] Proceedings Nat. Hist. Soc. of Glasgow, April, 1878. (The (?) is Messrs. Young's.)
[2] September, 1873.
[3] Palæontology of E. Nebraska, Washington, 1872.
[4] Transactions of St. Louis Acad., 1858, vol. i.
[5] Sheet 23, Scotch Geol. Survey.
[6] *Ibid.* Explanation of Sheet 23.
[7] See foot-note 1.

1873. *Carinella cellulifera*, R. Etheridge, jun.
1876. *Goniocladia cellulifera*, R. Etheridge, jun.

This is a good typical genus and species, both well described.

Generic and Specific Ch.—Polyzoarium composed of angular, irregularly disposed anastomozing branches, strongly carinate on both aspects, but celluliferous only on one. No regular dissepiments; the branches bifurcate and reunite with one another to form hexagonal, pentagonal, or polygonal fenestrules of most irregular form. On each side the keel of the poriferous aspect are three alternating lines of cell-apertures.[1] The genus and species, for there is only one, is well illustrated in the GEOL. MAG. 1873.

1849. *Thamniscus*, King, Permian Foss.

1873. Mr. R. Etheridge, jun., indicates the possible existence of a species of this genus in our Scotch Carboniferous rocks. "The portions obtained are fragments of a robust, branching coralline, with a nearly circular section. . . . . The cells are very pustulose or wartlike, with prominent raised margins. . . . . The disposition of the cells and mode of branching is exceedingly like that seen in *Thamniscus dubius*, Schl. . . . . As the margins (of the cells) in the present form are decidedly raised and prominent, might it not probably be a species of *Thamniscus?* If it be a new species of *Polypora*, I would propose for it the specific designation of *P. pustulata*.[2]

1875. The Messrs. Young of Glasgow, after recording the opinions of Mr. Etheridge,[3] describe *Thamniscus Rankini*, Young and Young, inserting between the generic and specific names "Stem free, dichotomous, circular, about $\frac{1}{18}$ inch in diameter, branches in one plane. . . . . Cells arranged in spirals. . . . . Cell-apertures circular when entire, oval when worn; lower lip prominent. . . . . . Non-celluliferous aspect finely granulated, faintly striate." . . . . "The generic position of the fossil is uncertain. . . . Meanwhile, though strongly disposed to regard this fossil as a true *Hornera*, or a member of a closely allied genus, we think it safer to leave it in the Palæozoic genus." In this the Messrs. Young are wise, but younger and less cautious observers, on the strength of the many peculiar affinities which this species has to *Hornera*, would have eagerly embraced this opportunity. I cannot, however, regard this species as a Palæozoic *Hornera*, but I must candidly confess that it comes very near to the generic description accepted by Busk.[4]

Glauconome, Munster, syn. *Vincularia*, Def. 1829. *Glauconome*, Goldfuss, 1826. Revised by Lonsdale, 1839. *G. disticha*, Lonsdale, type of D'Orb.'s *Penniretepora; Acanthocladia*, King, 1849.

It is very doubtful whether this term can be used for other than Palæozoic Polyzoa. It was originally used by Munster for cylindri-

[1] GEOL. MAG. 1873 and 1876. Expl. of Sheet 23, Scotch Survey, p. 101.
[2] Explanation of Sheet 23, Appendix, p. 102.
[3] Ann. and Mag. Nat. Hist., May, 1875, p. 335, pl. ix. *bis*.
[4] Marine Polyzoa, pt. iii. Cyclostomata, p. 16.

cal forms, for the *Glauconome marginata*, Munst., in Goldfuss's Petrefac. of Germany, is given by Hincks as a synonym of *Cellaria fistulosa*, Linn. It was, however, established by Goldfuss, and afterwards revised by Lonsdale. M'Coy,[1] improving upon Phillips's[2] poor description, does not make any reference to the number of pores between the branchlets. In his later work he defines the genus more minutely thus:—

"Corallum composed of a narrow central stem, with numerous pinnules, or lateral branches *unconnected* with each other: both stems and branches have two rows of cells on one face, which is usually carinated between them, carina in some species tuberculated; opposite face striated."[3]

In a paper read at the Nat. Hist. Soc. Glasgow, the Messrs. Young describe several new species of *Glauconome*.

1875.	*Glauconome*	*marginalis*,	Young and Young.
	,,	*stellipora*	,, ,,
	,,	*elegans*	,, ,,
	,,	*aspera*	,, ,,
	,,	*flexicarinata*	,, ,,
	,,	*retroflexa*	,, ,,
	,,	*laxa*	,, ,,
1877.[4]	,,	*robusta*	,, ,,
1877.	,,	*elegantula*,	R. Etheridge, jun.

In describing *G. elegantula* Mr. Etheridge defines and criticizes the genus *Glauconome* with especial reference to the *Acanthocladia*.[5]

1875. *Hyphasmopora*, R. Etheridge, jun.[6]

The generic and specific characters of this new provisional genus are well described by Mr. Etheridge in the paper referred to. There is only one species—*H. Buskii*, and I am glad that after submitting the specimens to Mr. Busk, Mr. Etheridge followed his own judgment and established a new genus, rather than adopt the suggestion of Mr. Busk, "That the above resembled the genus *Vincularia*, Defrance"—adding afterwards, "It is probably the type of a new genus, perhaps allied to the latter." This beautiful species is found in several localities of Scotland, but I have found it in Yorkshire, and also in N. Wales. It cannot, however, be considered a common form anywhere.

1850. *Sulcoretepora*, D'Orbigny.

This genus has been accepted by Morris (Catal.) and by the Messrs. Young, of Glasgow, for certain species of Carboniferous Polyzoa. Morris gives the above date, but the Messrs. Young in their paper[7] say, "The genus *Sulcoretepora* was formed by D'Orbigny in 1847, with the following definition: Cells in furrows on one side of simple depressed branches."

[1] Syn. Carb. Foss. Ireland. [2] *Retepora pluma*, Geol. of Yorkshire.
[3] Brit. Palæozoic Foss.
[4] Proc. Nat. Hist. Soc. of Glasgow, 1878. Paper read 1877.
[5] "Notes on Carb. Polyzoa," Annals and Mag. Nat. Hist. vol. xx. 1877.
[6] Provisional Genus of Polyzoa, *ibid.* vol. xv. 1875.
[7] Proceedings of Nat. Hist. Soc. Glas. 1877.

All the Carboniferous species that have been referred to this genus have cells on both sides, and, as I have already referred one of the accepted species to another genus, I will deal now with the *Sulcoretepora Robertsoni*, Y. and Y. As there are characters in this species altogether different from any known species of *Ptilodictya*, the same reference for this, as appears feasible for *Flustra ? parallela*, Phill., is altogether out of the question. The *S. Robertsoni* has none of the characters in common with Phillips's species, and I should strongly recommend the Messrs. Young to construct for this typical species a new genus, especially so as "Between each pair of cells in a longitudinal series, 1 to 3 pores occur, normally above each cell-aperture, and in well-preserved specimens tubercles surround each cell-area more or less completely."[1] The *facies* of Phillips's species and the species of the Messrs. Young may at first sight appear identical, but the forms described by the later authors are destitute of the non-poriferous, rugose, and striated margins of *Flustra? parallela*. It is upon the presence of this particularly constant character that I refer Phillips's species to *Ptilodictya*.

Archæopora nexilis, De Koninck.

This genus and species, classified as it is with the Polyzoa, is a most peculiar one. I have not by me De Koninck's work for reference, and the remarks that I may offer upon the species—for I shall accept the genus without discussion — are the results of original investigation. The species is tolerably common in a few localities of Scotland. I have no record of it in this country except in doubtful fragments in Wales—and my type specimen was presented to me by Mr. John Young, and I believe I may safely conclude that this, with other specimens, was seen and approved of by De Koninck when he visited the Hunterian Museum of Glasgow.

Sp. Char.—Polyzoary adherent to stems of encrinites, shells, fragments of *Rhabdomeson*, *Ceriopora interporosa*, spines of Mollusca, etc., spreading irregularly, forming large patches, at other times mere minute specs; pores generally oval, separated from each other by smaller openings. I cannot call them 'interstitial or cænenchymal tubuli'—for that would convey a false impression, for pores and cells are netted together. The number of small openings surrounding a cell varies; sometimes there are as many as fifteen, in other places not more than five or seven. About twelve cells with their interposed pores occupy the space of a line and a half across the cells, from nine to ten in the same space in their length. The polyzoary is separated from the foreign objects to which it is attached by a very thin lamina formed by the bases of the cells. There is no evidence of tabulæ in thin sections, but the interjacent pores do not reach quite to the bases of the cells. I have never seen a specimen, on which a fresh colony is found spreading over an older one, but sometimes a colony of *Stenopora* is found upon the polyzoary of *Archæopora*. In a thin transparent section of a small fragment of another specimen, adherent to a portion of shell, a most peculiar

[1] *Ibid.* p. 167.

structure is revealed, which for a long time puzzled me, because the peculiar biserial cells appeared like an analogous structure referred to by Prof. Nicholson when describing *Carinopora Hindei*, Nich.[1] His figures, however, are said to be transverse, mine are longitudinal, or in a line with the bases of the cells. These tail-like processes are constant characters at certain intervals even in a very small section, and may help in the recognition of the genus in sections of limestone. At first sight *Archæopora* has the appearance of *Callopora incrassata*, as described and figured by Nicholson,[2] but a very little examination will show the difference between the two forms, whereas one is a Polyzoon and the other a Tabulate coral.

I have now gone over the whole of the recorded genera and species of British Carboniferous Polyzoa, with the exception of the *Fenestellidæ*. These having been so lately and so ably reviewed by Mr. G. W. Shrubsole, F.G.S., their omission from this report will not be so much felt as the omission of any of the other lesser known forms. Mr. Shrubsole, after very elaborate investigations, and after the careful comparison of nearly all the known so-called species, is inclined to restrict the twenty-six species to five typical ones, namely :[3]—

Fenestella plebeia, M'Coy	*Fenestella nodulosa*, Phillips.
,, *crassa* ,,	,, *membranacea*, ,, sp.
,, *polyporata*, Phillips.	

all the other "species" falling into the rank of synonyms of one or other of the five here received by him. But this does *not* confine the number of known species to five. When his labours on the family are completed several new forms will be described, together with at least two more species of *Polypora*—the results of laborious investigations in North Wales. There are also some references to the Polyzoa of the Carboniferous Limestone of the districts between Llanymynech and Minerva, N.W., in the lately published work[4] of G. H. Morton, F.G.S., Hon. Sec. of the Liverpool Geological Society.

Several other papers on special points, having reference to Polyzoa, have been published during the last ten or twelve years. The vexed question as to the Hydrozoal or Polyzoal affinities of *Palæocoryne* has been debated by Prof. Duncan,[5] Prof. Young, and Mr. John Young,[6] and by myself ;[7] but the question as to their real affinities is still an open one. Another paper by Mr. A. W. Waters,[8] entitled 'Remarks on some *Fenestellidæ*," contains some debatable matter, and the papers of Mr. Robert Etheridge, jun., on the genus *Glauconome*, Messrs. Young on the genus *Ceriopora*, and the paper on the "Perfect Condition of the Cell-pores and other points of structure,"[9] are valuable additions to our knowledge of Carboniferous Polyzoa. Before any attempt can be made to construct a system of classification which will embrace—naturally — the several genera of the

1 Annals and Mag. Nat. Hist., Feb. 1874, p. 81, figs. *f* and *i*.
2 New Devonian Foss., Geol. Mag., Vol. I. 1874, p. 2, Plate I.
3 "Carboniferous Fenestellidæ," Quart. Journ. Geol. Soc., May, 1879.
4 The Carb. Limestone and Cefn-y-fedw Sandstone, London, David Bogue, 1880.
5 Phil. Transac., 1869. ; Journ. Geol. Soc., 1873 ; Journ. Geol. Soc., Dec. 1874.
6 Journ. Geol. Soc. Dec. 1874.
7 Science Gossip, 1879.
8 Proc. of Manchester Geol. Soc., 1879.
9 Newspaper Report, Oct. 9, 1879.

Palæozoic Polyzoa, many, at present, very doubtful points must be cleared up by a more complete study of all the species of the Palæozoic and Mesozoic ages of our earth's history. It is a difficult matter with present classifications to place the genera of Palæozoic Polyzoa without doing violence to constructed definitions. In the absence, therefore, of any well-defined families in which the Carboniferous Polyzoa can be placed, I venture to group the whole of the forms under separate headings, which must be considered as provisional only. But to prevent any misconception as to the special characters of each group, I shall refer to the shape of the cell or zooecia especially, as the basis of my arrangement, allowing all the other characters to fall into their places as subordinate only.

Fam. I.—Fenestellidæ.

Primary Char.—Polyzoary forming small or large fenestrated or non-fenestrated expansions. Cells placed biserially, or alternate, so as to form branches or "interstices," similar in many respects to the genus *Scrupocellaria* among living Polyzoa: cells bladder-like, margin of mouth raised and covered? by "operculum" during the life of the animal. The nearest living representative cell among the British Polyzoa figured by Hincks [1] is that of *Alcyonidium albidum*, with which I can compare generally the cells of the *Fenestellidæ*. The following genera are grouped provisionally, many details having yet to be worked out:—

Genus I. Fenestella—*plebeia*, *polyporata*, *membranacea*, in which the cells are biserially placed.

,, II. Fenestellina—*nodulosa*, *actinostoma*, in which the cells are alternate, literally forming single rows.

,, III. Glauconome—Only some of the species studied.

Fam. II.—Polyporidæ.

Primary Char.—Polyzoary forming small and large fenestrated expansions. Branches robust, cells placed contiguously in a slanting direction over the branch, opening on one side only; the cells on the margins of the branches (younger cells) nearly of the same shape as in the *Fenestellidæ*; the older cells in the innermost portion of the branches much compressed, but never partaking of a tubular character.

Genus IV. Polypora.

The cell-structure of the following genera is such as to warrant their separation from the whole of the above genera, but they are not sufficiently studied, neither are their details so well worked out as to enable me to suggest a proper place for them at present.

Genus I. *Goniocladia*, Etheridge, jun.
,, II. *Synocladia*, ,, ,, } Two *most* distinct species.
Synocladia, Young and Young. }
,, III. *Hyphasmapora*, Etheridge, jun.
,, IV. *Thamniscus*, Young and Young.
,, V. *Sulcoretepora Robertsoni*, Young and Young.
,, VI. *Archæopora*, De Koninck.

All the above are types of distinct genera, and before they can be

[1] Brit. Marine Polyzoa, 1880, p. 500; vol. i. p. lxx; vol. ii. figs. 8 to 10.

properly placed, the Silurian, as well as the Permian Polyzoa, must be carefully studied in the way that I have already suggested.

For the present, too, I will catalogue the remainder of the Carboniferous genera, reserving for the future more detailed arrangements.

Genus VII. *Rhabdomeson*, Young and Young.
" VIII. *Ceriopora*, Morris.
" IX. *Berenicea*, M'Coy = *Ceramopora*, Hall.

I thus, for the present, conclude my summary of the British species of Carboniferous Polyzoa. It would have been comparatively easy for me to have made it longer—it would have been difficult indeed to have made it shorter. To the palæontologist the study of the Palæozoic Polyzoa opens up many very important biological details, for the connexion of the Polyzoa with the Graptolites is a question that must be dealt with in detail; and the relationship of the Palæozoic to all other Polyzoa must be grappled with intelligently and dispassionately; and for this purpose collectors could help either myself or others by furnishing materials for the study.

Attercliffe, Sheffield.

V.—On the Caves and Kitchen-midden at Carrigagower, Co. Cork.

By R. J. Ussher, Esq.

THESE caves, whose original mouths are now probably destroyed or concealed by rubbish, open at present into a quarry in a limestone knoll on the townland of Carrigagower ('Rock of the Goat'), three or four miles south of Middleton. They are not broad nor lofty, but have extensive ramifications, especially that one which opens into the north-west part of the quarry. At its eastern end, and at a depth of 20 feet from the surface, the quarry is crossed by a cave now exposed by the removal of its western side. This cave runs in the line of a joint or fissure, and penetrates the rock north and south. The floor of this cave, where it remains (through the northern half of the exposed portion), is of stalagmite resting on pale sandy clay that overlies the limestone bottom. On this stalagmite floor, among the *débris* of broken stalactites, loose charcoal was found, and, on removing a layer of the solid stalagmite, from one inch to two inches in thickness, much charcoal was found embedded in it with sandstone gravel and some shells of a small *Helix*, marking the horizon of an old floor that had been encrusted by the subsequent formation of stalagmite. The portion of the cave laid open appeared in its southern part to have had no stalagmite floor, but to have had an upward opening to the sky, through which an accumulation of brown surface-earth and kitchen waste had been introduced, extending downwards into the cave so as to have completely filled this vertical opening. The accumulation was uniform in character, containing much charcoal, often in large lumps, and a great profusion of bones and teeth of ox, sheep or goat, and pig, with some remains of horse, dog, and cat, and a few of hare and rabbit. The bones were usually broken. Their colour was generally yellowish, but often blackened, though they exhibited no appearance of dendrites. In some instances they appeared to have been burned, and charcoal was very frequently found adhering to them and in their interstices. Numbers of sea-shells occurred through the accumulation. Seven species of these were noted, the most common being limpet and periwinkle. Many shells of the common garden-snail also occurred. With the above were found several articles of human use. Sharpening-stones of different sizes, flat circular pebbles, hammer-stones, flint-flakes artificially chipped, a fragment of wheel-made pottery, two iron knives of an antique form, an iron chisel, and a large flat-headed iron nail, some slag and a piece of jet (?). A portion of a jet bracelet had previously been found in the same brown surface-earth close to this spot. J. J. Smyth, Esq., to whose kind assistance we are much indebted, found in a recess, close to the above spot, a portion of the upper stone of a quern imbedded in earth. Near the centre of the quarry, a portion of a cave remains that has been partly quarried away. In this was discovered, with bones of deer and ox, part of another stone, very similar to the above portion of a quern, with a flat surface and a circular hole in it, though not in a direction exactly perpendicular to the surface. In the surface of an adjoining field a deeply indented arrow-head of flint was found some time since, and labourers employed on the spot say that triangular chipped flints have frequently been met with there. The surface-earth around the quarry contains many bones of ox, goat, and pig, showing that the spot had been the site of some human habitation for a considerable lapse of time.

Further explorations in this cavern have been postponed, but will be resumed presently.

The following is an Extract from a Report by Robert Day, Esq., F.S.A., on the Implements found at Carrigagower, Co. Cork.

The iron objects are peculiarly interesting, as examples of very early domestic articles—comprising a chisel and two knives. The larger of these has a portion of the wooden haft still adhering to it, and the turn-up on the handle part, designed for securing it effectually, occurs on a larger knife in my collection which was found at Larne, Co. Antrim. These objects lack the peculiar blue or cobalt patina that is so frequently found on iron tools from Irish crannogs. The oblong stone with polished sides is a burnisher or whetstone, upon which probably the knives were sharpened. The broken stone may either have been a hone stone or a chisel-shaped celt. If it was found in the same deposit as the iron objects, I should say it was another polisher, as it is not probable that a chisel of the advanced iron type would be found in conjunction with one of stone. Two of the natural pebbles are hammer-stones, and the third, with its ground and partly polished face, is one of a type commonly met with in the North of Ireland. In this the central depression is barely defined, but in others it is much more fully developed, so that I have long come to the conclusion that, while serving some purpose (perhaps for grinding the broken points of arrow-heads), they were made to pay a double debt, and served as amulets! I noticed upon the broken bit of pottery what looks very like a worn-out inscription in Roman capital letters. This is best seen with a pocket lens. The bit of jet (?) may be jet or coal ; I am not competent to give an opinion. The fragments of flint are all artificial. Among them is the base (showing the bulb of percussion) of a worked flake. These flint-flakes were used down into the iron age, and we have here another proof of the fact. The bone scoop sent by Mr. Smyth is, from the character of the texture or structure of the bone, altered by exposure and time, as it is unquestionably older than the apple-scoops which schoolboys made in the present century, and which it closely resembles. I have another like it, from the Lough Revel Crannog, Co. Antrim, with cobalt patina. This from Rathcoursey (Carrigagower) is ornamented, and the flint arrow-head found there is small, beautifully chipped, and of the scarce and deeply indented type. The iron nail is very curious, with a head like a horse nail.

NOTICES OF MEMOIRS.

British Association Reports. Abstracts of Papers read before Section C. (Geology) Swansea.

I.—On the Action of Carbonic Acid on Limestone.

By Professor Boyd Dawkins, F.R.S.

Caves in the limestone are to be looked upon as subterranean watercourses, which are produced partly by the dissolving action of the carbonic acid in the rain-water, and partly by the mechanical action of the streams flowing through them. The insoluble carbonate of lime in the rock is changed into the soluble bi-carbonate and carried away in solution. The additional atom of carbonic acid, however, is in a condition of unstable chemical combination, and if it be removed either by evaporation or by the action of the free current of air, the insoluble carbonate of lime at once is deposited. Hence it is that some caverns have their walls covered with a drapery of stalagmite and the little straw-like pendants from the roof formed round the edges of each drop gradually become developed into columns of various sizes. The stalagmitic pedestals also rise from the floor where a line of drops falls from the roof and ultimately unite with the column let down from above. On the surface, too, of the pools an ice-like sheet of stalagmite gradually shoots across from the sides, and sometimes where the water is still covers the whole surface. Admirable illustrations of all these processes are to be seen in the caves of Pembrokeshire, and especially in the Fairy Cave on Caldy Island.

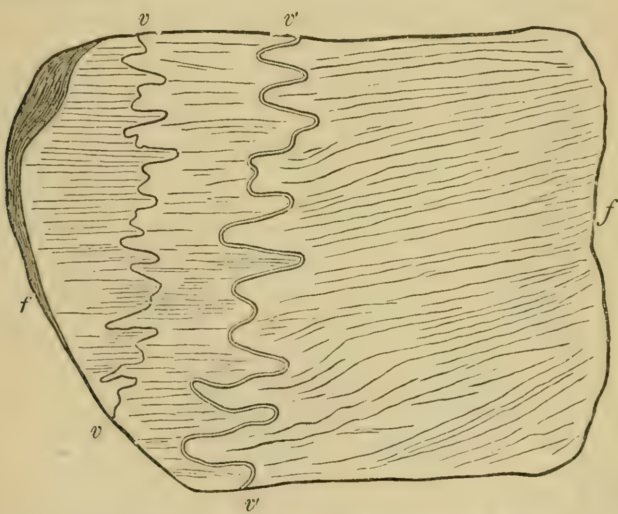
The rate of the accumulation of carbonate of lime depending primarily upon the access of water and the free access of air, both being variable, varies in different places. Sometimes it is very swift, as for example in the Ingleborough Cave, where a series of observations by Professor Phillips, Mr. Farrar, and myself extending over the years from 1845 to 1873 give the annual rate at ·2946 inch. It is obvious, therefore, that all speculations as to the antiquity of deposits in particular cases based on the view that the accumulation is very slow, are without value.

The mountain limestone ravines and passes are to be viewed in the main as caverns formed in the manner above stated, which have lost their roofs by the various sub-aerial agents which are ever at work attacking the surface of the limestone. If any of these be examined, it will be seen that the tributary caves open on their sides, and in some cases the ravine itself is abruptly terminated by a cavern.

II.—On a Fragment of Mica Schist.

By Professor W. J. Sollas, M.A., F.R S.E., F.G.S.

THE author called attention to some appearances presented by a fragment of mica schist, pointed out to him by Prof. William Ramsay, Ph.D., while walking on the beach at Bodö, Norway. It is a tabular fragment, showing fine foliation-laminæ, and traversed by two undulating veins of quartz, the undulations are very high and narrow, eight complete ones occurring along a distance of ten inches in a straight line.



Face of Fragment of Mica-Schist, Bodö, Norway.

f f planes of foliation. *v v* and *v' v'* folded veins of quartz, crossing the planes of foliation. (Scale $\frac{1}{4}$.)

The planes of foliation correspond to the bedding in the rocks of the neighbourhood (amongst which this same phenomenon was afterwards noticed). The folded quartz vein was at one time straight and cut across the foliæ at right angles; the folding must have been accomplished by compression of the schist at right angles to its foliæ, and by measuring the length of the quartz vein between two points along its undulations (26 inches) and also directly along its path

(10 inches) one finds the amount of compression which has taken place (13 : 5). The argument is the same as that used by Dr. Sorby for the bed of quartzite folded in the slate of Devonshire.

III.—On the Island of Torghatten.

By Professor W. J. Sollas, M.A., F.R.S.E., F.G.S.

The author described the results of a visit which he made to this island in July, 1880. The platform from which the peak of the island rises is a narrow plain of marine denudation, produced when the island was submerged 375 feet below its present level. The tunnel which traverses it is a sea-cave excavated between two master-joints. The floor of the cave is covered with angular blocks of gneiss, which have fallen from the roof since the elevation of the cave-floor above the sea-level; the blocks have fallen far more rapidly at the entrances of the cave than in the interior, and, as a consequence, the roof rises from the middle towards each end of the tunnel, and so does the angular debris, which thus forms at each entrance a vast sloping mound. The vast quantity of fallen material is an interesting indication of what has been accomplished by simple mechanical disintegration since the island was raised above the 375 feet level. The joints are the most important factors in denudation; excepting moutonnéed faces, the author considers most of the bare rock faces which constitute the surface of Northern Norway are merely exposed joint planes. He has seen joints in the same rock, and having the same direction, extending from a few feet to over a thousand, and surface features in parallelism with them from a facet not a yard across to precipices over a 1000 feet high.

IV.—On the Hiatus said to have been found in the Rocks of West Cork.

By G. H. Kinahan, M.R.I.A.,
President of the Royal Geological Society of Ireland.

The paper was commenced by a table of the different classifications of the Cork Rocks.

Griffith.	Jukes.	Hull.
Carboniferous Slate.	Carboniferous Slate.	Carboniferous Slate. Coomhoola Grits.
Yellow Sandstone.	Upper Old Red Sandstone.	Kiltorcan Beds.
Old Red Sandstone.	Lower Old Red Sandstone.	Glengariff Beds (Silurian.)
Silurian.	Glengariff Grits.	

From the table it is apparent that although using different group-names Griffith's and Jukes' classifications are essentially similar, while Prof. Hull's classification is materially different from both; although by adopting for his new groups, names very similar to those of Jukes, a careless reader might suppose his classification was similar to that of Jukes and Griffith.

The paper went on to point out that the supposed hiatus rested on the conclusions of Prof. Hull, which the author reviewed in order. First, that the hiatus and unconformability, it was understood, were supported by the observations of Messrs. O'Kelly and McHenry at Kenmare and Glengariff Bays; but one of these geologists, however, contradicts this, while the second declines to give an opinion. The second, referred to well-known unconformabilities outside the limits of the typical West Cork rocks; these on account of the places in which they occur, the author was of opinion did not favour the idea of a hiatus. The third was a statement that the plotting on the maps of the Geological Survey proved an unconformability; the lines, however, to which Prof. Hull was supposed to have referred are only the conventional lines in common use to indicate folds and flexures in contorted areas; and are fully explained in the sections of Jukes and his assistants. The fourth is, that there are abrupt changes in the rocks forming Prof. Hull's different groups—this, however, was shown to be improbable, as the Carboniferous Slate of Griffith graduates so imperceptibly into his Yellow Sandstone, and the latter into his Old Red Sandstone (the upper member of Prof. Hull's "Glengariff Beds"), that the respective boundaries adopted on the Government maps are arbitrary, and depend solely on the colours of certain beds.

V.—The Old Red Sandstone of the North of Ireland.

By G. H. Kinahan, M.R.I.A.,

President Royal Geological Society of Ireland.

In the Geol. Mag. for August, 1880, page 381, appears the abstract of a paper "On the Old Red Sandstone of the North of Ireland," by Mr. F. Nolan (read before the Geological Society of London, June 23rd, 1880). In this communication my classification is cautiously acknowledged, although when I first published it in my preface to the Geology of Ireland, Prof. Hull, in criticising it in the Geological Magazine, brought forward most ingenious evidence to show that I was mistaken.

According to the published Map of the Pomeroy District (Ireland, Sheet 34), the Old Red Sandstone of Shanmaghry, two miles S.E. of Pomeroy, not only rests on the fossiliferous Pomeroy rocks, but graduates into them. I, however, would suggest that the position of the boundary is inaccurate, and that the Old Red Sandstone extends a little farther north into the townland of Aghafad, its base being a friable red conglomerate that rests unconformably on the fossiliferous beds a little to the north of it.

I cannot understand on what reasoning it has been assumed that the "Kiltorcan beds" of Professor Hull, which are said to be the equivalents of Griffith's "Yellow Sandstone," can be supposed to be absent in the North of Ireland. They were found there years ago by Griffith and others; and there are good exposures, in different places in Tyrone, Fermanagh, etc., of rocks lithologically identical with those in the Kiltorcan district, Co. Kilkenny; while these rocks, and also those at Kiltorcan, have similar relations to the Carboniferous Limestone. Furthermore, it is stated in the abstract referred to that the Upper Conglomerates are supposed to represent "the Upper Old Red Sandstone of Waterford," yet Haughton, Baily, and others, years ago, proved that the Upper Old Red Sandstone of Waterford contains a like assemblage of fossils to those at Kiltorcan, Co. Kilkenny. This is a paradox that needs explanation.

As the Carboniferous Slate of Cork County is the equivalent of the Carboniferous Limestone and its associated sandstones and shales, the Calp sandstones of Ulster must necessarily in part represent the Carboniferous Slate; but it is erroneous to state they are the equivalents of it or of the Coomhoola Grits, especially the latter, as those who are acquainted with the geology of West Cork are aware that the last-mentioned name was applied by Jukes to groups of grits that may occur on different horizons in the Carboniferous Slate.

VI.—Note on the Range of the Lower Tertiaries of East Suffolk.

By W. H. Dalton, F.G.S., of H.M. Geological Survey.

The Crags and Drifts of East Suffolk prevent more than an approximate delineation of the outcrop of the Chalk from beneath the Lower Tertiaries.

The London-clay disappears from the surface a little west of Orford; but the deep boring at Sir E. Lacon's Brewery in Yarmouth, made in 1840, passed through 170 feet of estuarine deposits, and then no less than 305 feet of London-clay and 51 of Reading beds, before reaching the Chalk. There could therefore be hardly a doubt of the continuity of the Eocene beds between Orford and Yarmouth, although their boundary-line might be for some part of its length outside of the present coast: indeed, in published maps, most of the interval is coloured as Chalk.

The inhabitants of Suffolk are, however, awaking to the disadvantages of a water-supply derived from ponds and sewage-tainted sands, and consequently Artesian wells, carried down into the Chalk, are increasing in number.

The accounts of these wells (which will duly appear in the Memoirs of the Geological Survey) give the following indications of the position of the outcrop of the Chalk:—

At Easton Park, Framlingham, Beccles, and Norwich, the Chalk is covered directly by Crag or Drift.

At Woodbridge, Saxmundham, Bramfield, and Yarmouth, a greater or less thickness of Lower Tertiary beds is present, and their boundary is probably three or four miles in and from these points.

At Hoxne, a few feet of 'green clay' lying directly on the Chalk may possibly be an outlier of the Reading beds.

The Lower Tertiaries, thus outlined, possess no special interest, except that, being impervious clays, they cut off impure surface waters, and are easier to bore through than the loose sands, etc., overlying them.

The plane of the Chalk surface, whether under or beyond the Lower Tertiaries, is sufficiently uniform to render calculation of its depth in any part of the district an easy process. In the Bramfield boring, the latest of the series, the Chalk was reached at 48 feet below the ordnance datum, calculation from the three nearest points —Beccles, Framlingham, and Saxmundham—indicating $52\frac{1}{2}$ feet.

VII.—On some Pre-Cambrian Rocks in the Harlech Mountains, Merionethshire.

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

During an excursion into the Harlech Mountains in the summer of last year, I recognized, near the centre of the well-known anticlinal of Cambrian rocks, another group of rocks, which appeared to me to underlie the former, and to be part of a pre-existing formation. On further examination I noticed also that many of the fragments in the conglomerates at the base of the Harlech Grits seemed to be identical with the rocks below, and to have been derived from some such pre-existing group. Subsequent microscopical examination of some of the fragments, and of the underlying rocks, tended strongly to confirm this view. In order, however, to satisfy myself more fully on this point, I revisited the area this summer, accompanied by my friends, Prof. Hughes, Mr. Tawney, and Dr. R. D. Roberts, and the result has been to entirely confirm my previous conclusions. This discovery is of considerable importance, as it enables us to compare the thickness of the Cambrian rocks of North Wales more satisfactorily than has been hitherto possible with those of South Wales, and to realize more clearly the early physical conditions of the areas. Hitherto it seemed doubtful what the actual thickness of the Harlech Group could be, and very different estimates have been given. It now becomes possible to give a perfectly correct estimate, and it is satisfactory to find that it approximates far more nearly with that made out in other Welsh areas, than was previously supposed.

The points where these older rocks come to the surface mainly occur along a line running nearly due N. and S. from Llyn-Cwmmynach to about two miles to the S.W. of Trawsfynnyd. Along this line the anticlinal is much broken, and denudation has taken place to a very considerable extent. It is mainly in consequence of this that the Pre-Cambrian rocks are exposed. The so-called intrusive felstones marked here on the Survey Maps are part of the Pre-Cambrian group, and are not intrusive in the Harlech rocks. They are highly felsitic rocks, for the most part a metamorphic series of schists, alternating with harder felsitic bands, probably originally felsitic ashes. They alternate with bands of purplish slates, which I once supposed might have been dropped amongst them by faults, but which I now think also belong to the Pre-

Cambrian group, as in the Pebidian rocks at St. Davids, and elsewhere. There are also some other exposures of the Pre-Cambrian rocks in the adjoining areas, and one very interesting section was carefully examined by Prof. Hughes and myself, to the east of the Trawsfynnydd road, between Caean Cochion and Penmaen, where the Cambrian conglomerates could be seen resting unconformably upon the older series, and large masses of the latter found plentifully in the conglomerates.

VIII.—On the Sandstones and Grits of the Lower and Middle Series of the Bristol Coal-field.

By Edward Wethered, F.G.S.

THE Bristol Coal-field is noted for its series of grits and sandstones, and these probably have their equivalents, in the South Wales and Forest of Dean Coal-fields, as well as in that of Somersetshire. They serve as stratigraphical landmarks; and it was the object of the paper (1) to compare the grits of the above Coal-field with one another, with a view of ascertaining whether there were distinguishing features which might enable them to be respectively determined, and assist in correlation. (2) To examine the chemical and physical conditions. (3) To note changes which occur when rocks are in contact with carbonaceous matter. The first point raised was the application of the term grit and sandstone. The author confirmed the statement of Mr. Sorby, in his presidential address to the Geological Society in 1880, to the effect that the Carboniferous Sandstones were composed of angular grains. Of those examined by the author, the grains of the Millstone Grit were the least angular. It was also pointed out, that as rocks show such variation of coarseness in the same deposit, this could not be taken into consideration as a test for grit. It was therefore suggested that the term grit should be confined to those rocks which show angularity of grains, irrespective of coarseness; and the term sandstone to those which are composed of rounded grains (*i.e.* from which the angularity has been removed). In any case, the term grit must be more generally applied to Carboniferous rocks than has been the case hitherto.

Reference was then made to 'duns,' which was defined as those Carboniferous beds intermediate between grit or sandstone and clay. In mining operations, where the 'driving' of branches was by contract, questions arose between employer and employed, in the case of 'hard duns,' as to whether it is 'stone' or 'duns,' double price being paid for driving in the former. It was also important for geological purposes, in the construction of sections, that there should be an easy and ready test for this determination. The author suggested that the scratching of glass would be a suitable one, which would represent a hardness of 7 for rock which scratches glass.

The chief deposits of rock in the Coal-field were then referred to in ascending order, commencing with the Millstone Grit. Several samples of this, taken from Brandon Hill, gave from 97·4 to 98·5 per cent. of silica. In places it is used for brick-making, being mixed with the other material to increase the proportion of silica. It was pointed out that there were other beds higher up in the Coal-measures which would do equally well, and in some cases better, for this purpose. The paper next referred to the 'Pennant Grit.' There is considerable difficulty in defining the limits of this deposit, but it was certainly not 2000 feet thick, as some authors had stated. The paper places the thickness at about 970 feet; but the middle or Pennant series of Coal-measures, so called on account of the Pennant being so extensively developed in this division, was about 2000 feet thick, and this, probably, was the origin of the mistake regarding the thickness of the Pennant.

The 970 feet of rock above referred to as the Pennant grit, was only entitled to that name as a local distinction. It was nothing more than an extraordinary development of a local measure grit: the 'Dexall grit,' of the lower series, for instance, was quite as much a 'Pennant,' if that term is to distinguish a certain class of rock.

After a careful examination of the rocks of the Coal-field, the author had come to the conclusion that, owing to the great similarity of Carboniferous arenaceous rocks occurring at different horizons, there was risk of serious error, in relying upon them for correlation or as stratigraphical landmarks. The proportion of silica could be sometimes used as a guide in determining one from another, but little reliance could be placed on it over a large area, as so many beds contained nearly the same amount.

The author's analysis showed the first 50 feet of the Pennant to contain 90 per cent. of silica; but after this, for a considerable thickness, 'good Pennant' varied from 84 to 89 per cent. in the proportion of silica contained in it.

The paper then referred to changes in the Carboniferous rocks, when in contact with carbonaceous matter. The author found that the per-centage of alumina increased, and this mostly as a silicate. By comparing the analysis of duns and shale from the district with that of the rocks, the same constituents were found to be present, the great difference being in the greater proportion of alumina in duns and shale. As a rule, the latter beds were to be found near coal; but in cases where rock followed, the author found that as it neared the coal it became more fissile and argillaceous.

This change was ascribed to the action of carbonic acid gas, generated by decomposing vegetation on silicates. The analysis of the rocks given showed them to have been formed from the denudation of older silicate rocks, and the action of carbonic acid on such sediment would be to readily decompose all silicates with the exception of silicate of alumina, which would thus increase in proportion to the whole, and give rise to beds of the composition of duns and shale.[1] To this cause the author attributed the formation of the latter deposits, and contended that although they may occur apart from carbonaceous matter, there is no proof that it was never present, and that it may not have been destroyed by decomposition.

[1] The writer is not now dealing with the hydrocarbons which shales sometimes contain.

REVIEWS.

I.—Odontornithes: A Monograph on the Extinct Toothed Birds of North America. By Prof. O. C. Marsh, F.G.S., of Yale College. Memoirs of the Peabody Museum of Yale College, New Haven, Connecticut, 1880. Royal 4to. pp. 202, with 34 Plates and 40 Woodcuts.

THE science of Palæontology is deeply indebted to Professor O. C. Marsh for his numerous and valuable contributions to its literature on the American Continent.

What Professors Owen and Burmeister have done towards the elucidation of the South American Pleistocene Edentata—Professor Marsh has accomplished for a far wider range of forms and of formations on the North American Continent.

So long ago as February, 1876, we published an interesting account in the pages of the Geological Magazine (Decade II. Vol. III. pp. 49–53, Plate II.), written by Prof. Marsh himself, of these singular toothed birds, the *Ichthyornis dispar*, Marsh, the *Hesperornis regalis*, Marsh, and the *Apatornis celer*, Marsh, all from the Cretaceous beds of Western Kansas.

The work before us is the long-anticipated and exhaustive Monograph on these toothed birds, and certainly, as a scientific publication, it surpasses any which have already appeared devoted to palæontology.

Would that our own Government were equally alive to the interests of science! Painful indeed is the comparison between the Memoirs and publications of our own Survey and those like the "Geological and Geographical Atlas of Colorado," by Dr. F. V. Hayden,[1] with its magnificent maps and plates—"The United States Geological Exploration of the Fortieth Parallel, by Clarence King,"[2] with 28 plates, 12 analytical maps, and 800 pages of letterpress—or, Prof. Marsh's present magnificent Monograph, intended to form Vol. VII. of the Publications of the Survey of the 40th Parallel.

Subjoined is an alphabetical list of all the species of birds now known from the Cretaceous deposits of North America. Many of these are represented, at present, only by fragmentary remains, their near affinities are therefore more or less uncertain. The list contains eight genera and twenty species.

Apatornis celer,	Marsh,	1873.	*Icththyornis lentus*,	Marsh,	1877.
Baptornis advenus,	,,	1877.	——— *tener*,	,,	1880.
Graculavus velox,	,,	1872.	——— *validus*,	,,	,,
——— *pumilus*,	,,	,,	——— *victor*,	,,	1876.
Hesperornis regalis,	,,	,,	*Laornis Edvardsianus*,	,,	1870.
——— *crassipes*,	,,	1876.	*Palæotringa littoralis*,	,,	,,
——— *gracilis*,	,,	,,	——— *vagans*,	,,	1873.
Ichthyornis dispar,	,,	1873.	——— *vetus*,	,,	1870.
——— *agilis*,	,,	,,	*Telmatornis priscus*,	,,	,,
——— *auceps*,	,,	1872.	——— *affinis*,	,,	,,

The present volume is the first of a series of Monographs designed to make known to science the Extinct Vertebrate Life of North America. In the investigation of this subject, the writer

[1] See Geol. Mag. 1878, Decade II. Vol. V. p. 365.
[2] See Geol. Mag. 1879, Decade II. Vol. VI. p. 467.

has spent the past ten years, much of it in the field, collecting, with no little hardship and danger, the material for study, and the rest in working out the characters and affinities of the ancient forms of life thus discovered.

During this decade, the field work, extending from the Missouri River to the Pacific Coast, has so predominated, as the subject unfolded, that a plan of gradual publication became a necessity. The more important discoveries were briefly announced soon after they were made, but only where specimens on which they were based admitted of accurate determination. The principal characters of the new groups were next worked out systematically and published, with figures of the more important parts. When the investigation of a group is completed, the results, with full descriptions and illustrations, will be brought together in a monograph. This system has been carried out with the *Odontornithes*, and will be continued with the other groups. The investigation of several of these is now nearly completed, and the results will soon be ready for publication.

The material is abundant for a series of monographs on the marvellous extinct vertebrates of this country, and the results already attained are full of promise for the future. A somewhat careful estimate makes the number of new species of extinct vertebrates collected since 1868, and now in the Yale College Museum, about 1000. Nearly 300 of these have already been described by the writer, and some have been noticed or described by other authors, but at least one-half remain to be investigated.

Among the new groups brought to light by these researches, and already made known by descriptions of their principal characters, are the following, which will be fully described in subsequent volumes of the present series.

The first Pterodactyles, or flying reptiles, discovered in this country, were found by the writer in the same geological horizon with the *Odontornithes*, described in the present memoir. These were of enormous size, some having a spread of wings of nearly twenty-five feet; but they were especially remarkable on account of having no teeth, and hence resembling recent birds. They form a new order, *Pteranodontia*, from the type genus *Pteranodon*. Of this group, remains of more than six hundred individuals are now in the Yale College Museum—ample material to illustrate every important point in their osteology.

With these fossils, were found also great numbers of Mosasauroid reptiles, a group which, although rare in Europe, attained an enormous development in North America, both in numbers and variety of forms. Remains of more than fourteen hundred individuals, belonging to this order, were secured during the explorations of the last ten years, and are now in the Museum of Yale College.

The most interesting discoveries made in the Jurassic formation were the gigantic reptiles belonging to the new sub-order *Sauropoda*, including by far the largest land animals yet discovered. Another remarkable group of large reptiles found in the same formation were the *Stegosauria.* Other Dinosaurs from the same horizon, the "Atlantosaurus beds," show that this was the dominant form of vertebrate life in that age, and many hundred specimens of these reptiles are now in the Yale Museum. In a lower horizon of the same formation, the "Sauranodon beds," were found the remains of a peculiar new group of reptiles, the *Sauranodontia,* allied to Ichthyosaurus, but without teeth.

In the Eocene deposits of the Rocky Mountains the writer discovered a new order of huge mammals, the *Dinocerata.* Remains of several hundred individuals were secured, and a monograph on the group will follow the present memoir. In the same formation were found the remains of another new order of mammals, the *Tillodontia,* in many respects the most remarkable of any yet discovered. In the same Eocene deposits were secured the first remains of fossil *Primates* known from North America, as well as the first *Chiroptera,* and *Marsupialia.* Abundant material also was found in the same region to illustrate the genealogy of the Horse, and a memoir on this subject is in course of preparation.

The remains of birds are among the rarest of fossils, and very few have been discovered except in the more recent formations. According to present evidence, the oldest known birds were imbedded in the Jurassic deposits of Europe, which have yielded two individuals belonging to the genus *Archæopteryx,* so well preserved that the more important characters can be determined. The only other remains of birds found in the Mesozoic formations of the Old World are a few specimens from the Cretaceous of England, which are too fragmentary to throw much light on the extinct forms they represent.

The earliest traces of birds hitherto found in the strata of this country are from the Cretaceous, although we may confidently predict their discovery in the Jurassic beds, if not at a still lower horizon. There is at present no evidence whatever that any of the three-toed impressions met with so abundantly in the Triassic of the Connecticut Valley, described as the footprints of Birds, were made by Birds; and the proof now seems conclusive that nearly all of them are the tracks of Dinosaurian reptiles, bones of which occur in the same deposits.

In the Cretaceous beds of the Atlantic coast, and especially in the Green-sand region of New Jersey, various remains of birds have been found, and described by the writer. These fossils, although often in excellent preservation, occur mainly as isolated bones, and hence their near affinities have not as yet been determined with certainty.

Along the eastern slope of the Rocky Mountains, and especially on the adjoining plains in Kansas and Colorado, there is a series of Cretaceous strata remarkably rich in vertebrate fossils. The deposits are all marine, and away from the mountains, they lie nearly horizontal. They have suffered much from erosion, and are still wasting away, especially along the river valleys. These beds consist mainly of a fine yellow Chalk and Calcareous shale, both admirably adapted to preserve delicate specimens, and here have been found the extinct Birds which form the subject of the present memoir.

The geological horizon of the known *Odontornithes* is in the Middle Cretaceous, and corresponds to the strata named by the writer the "Pteranodon beds." The latter are included in subdivision number three in Meek and Hayden's section. The accompanying fossils are Mosasauroid reptiles, which are very abundant; Plesiosaurs, allied to *Pliosaurus*, Pterodactyles, of the genus *Pteranodon*; and many fishes. With these occur *Rudistes*, and occasionally *Ammonites*, *Belemnites*, and various other Cretaceous invertebrates.

The first bird fossil discovered in this region was the lower end of the tibia of *Hesperornis*, found by the writer in December, 1870, near the Smoky Hill River in Western Kansas. Specimens belonging to another genus of *Odontornithes* were discovered on the same expedition. The extreme cold, and danger from hostile Indians, rendered a careful exploration at that time impossible.

In June of the following year, the writer again visited the same region, with a larger party and a stronger escort of United States troops, and was rewarded by the discovery of the skeleton which forms the type of *Hesperornis regalis*, Marsh. Various other remains of *Odontornithes* were secured, and have since been described by the writer. Although the fossils obtained during two months of exploration were important, the results of this trip did not equal our expectations, owing in part to the extreme heat (110° to 120° Fahrenheit, in the shade), which, causing sunstroke and fever, weakened and discouraged guides and explorers alike.

A considerable part of these Cretaceous deposits still remained unexplored, and in the autumn of 1872, a third expedition through this territory was undertaken by the writer, with a small party. Additional specimens of much interest were secured, including the type of the genus *Apatornis* and one nearly complete skeleton of *Hesperornis*,—an ample reward for the hardship and danger incurred.

The specimens thus secured by these various expeditions have since been supplemented by important additions collected in the same general region by different parties equipped and sent out by the writer, who no longer could give his personal supervision to work in that field. The fossil birds procured in this region since 1870, by these different expeditions, include remains of more than one hundred different individuals of *Odontornithes*. These are all in the Museum of Yale College, and form the material on which the present volume is based.

A study of this extensive series of bird remains brings to light the existence in this class of two widely separate types, which lived together during the Cretaceous period in the same region, and yet differed more from each other than do any two recent birds. Both of these types possessed teeth, a character hitherto unknown in the class of birds, and hence they have been placed by the writer in a separate sub-class, the *Odontornithes*. One of these groups includes very large swimming birds, without wings, and with the teeth in grooves (*Odontolcæ*), and is represented by the genus *Hesperornis*. The other contains small birds, endowed with great powers of flight, and having teeth in sockets (*Odontotormæ*), and biconcave vertebræ; a type best illustrated by the genus *Ichthyornis*. Other characters, scarcely less important, appear in each group, and we have thus a vivid picture of two primitive forms of bird structure, as unexpected as they are suggestive. A comparison of these two forms with each other, and with some recent birds, promises to clear away many difficulties in the genealogy of this class, now a closed type; and hence they are well worthy of the detailed description and full illustration here devoted to them.

The fossil birds now known from the Cretaceous deposits of this country are included in nine genera, and twenty species. These have all been described by the writer, and are represented at present by the remains of about one hundred and fifty different individuals. There is evidence of a rich and varied Avian fauna in North America during Mesozoic time, and likewise it indicates what may be expected from future discoveries.

We heartily thank Prof. Marsh for this grand work, and shall look forward with great pleasure to the issue of the succeeding volumes of the Peabody Memoirs on the extinct *Pteranodontia*, the *Sauropoda*, the *Sauranodontia*; the *Dinocerata*, the *Tillodontia*, and the ancestors of our living Horse.

II.—A Monograph of the Fossil Corals and Alcyonaria of Sind. Collected by the Geological Survey of India. By P. M. Duncan, M.B. (Lond.), F.R.S. (London: Taylor & Francis, 1880.)

In their great work on the Nummulitic Group of India (1853), MM. d'Archiac and J. Haime fully described and figured a series of fossil corals from Sind, but their stratigraphical position and localities were not strictly determined, and they were merely referred to the Nummulitic formation, of the Hala Mountains. Prof. Duncan re-examined this collection in 1863, and published the results in the Journal of the Geological Society (1864), and described the new species in the Annals of Natural History for the same year. The collection forming the subject of the present Monograph is due to the labours of Messrs. W. T. Blanford and Fedden, who have carefully recorded the geological position and localities from whence the specimens were obtained, so that we are now furnished with clear descriptions of the species from the coral-bearing series of Sind, and their relations to the representative forms elsewhere—a comparison which the author's previous researches have enabled him more readily to make.

The classification followed in the Monograph is principally that adopted by M. Edwards and J. Haime with some modifications, the result of the experience of zoophytologists since that book was published. The larger number of the 136 species of corals described belong to the Madreporaria-aporosa, and the rest to the Madreporaria-perforata.

According to Prof. Duncan these corals form five very natural faunas, and that of each geological series is separable from the others, community of species being exceptional, only one species is found to be common to more than one series. These five faunas are: the Cretaceous (below the Trap), the Nummulitic (Ranikot), the Upper Nummulitic (Khirthar), the Oligocene (Nari), and the Miocene (Gáj) series.

The general geology, palæontology, and stratigraphical relations of the Coralliferous series of Sind (pp. 3–14), are chiefly abstracted from the "Manual of the Geology of India," by Messrs. Medlicott and W. T. Blanford, and other memoirs of the latter author.

With regard to the distribution of the 136 species of corals in the above five divisions, Prof. Duncan records 9 from the Cretaceous, 50 from the Ranikot, 16 from the Khirthar, 20 from the Nari, and 41 from the Gáj series.

Of the Cretaceous corals the most numerous are the Litharææ, next the Caryophylliæ, and then the Smilotrochi; the facies of the fauna is more Eocene than Cretaceous. "Taken as a fauna, this assemblage of species does not indicate the conditions sufficient to form a coral-limestone. A shallow-sea formation, where the corals lived under not very favourable conditions, occurred." Of the 50 corals from the Ranikot series, 7 species are identical with those from European Eocene deposits containing *Num. planulatus* and *Cerithium giganteum*, and 5 are closely allied to those from the same deposits or on slightly higher horizons.

Three of the 16 species found in the Khirthar series are common to it and the European and West Indian Eocene, and three are allied to others in Europe. Of the 20 species from the Nari series, five are found in the Upper Nummulitic and Oligocene of Europe, and one occurs at a higher horizon.

The 41 species from the Gáj series belong both to ancient and modern genera, but there are no recent species. "The absence of so many of the modern genera of the Pacific and Red Sea, considered with the evident antiquity of many of the genera, indicates a Miocene age. Many of the forms are representatives of the West Indian Miocene."

Prof. Duncan remarks, "Not only has the examination of the fossil corals lately obtained by the Geological Survey of India from Sind added to the number of the Eocene species, but it also indicates that there is an upper series of coralliferous strata which merits the title of Oligocene. Again, other species clearly prove, what was formerly suggested was probably the case, that an important Miocene coral-fauna lived on the same area as that which had been previously occupied by the earlier Tertiary forms."

This monograph will therefore form a valuable addition to the "Palæontologia Indica," and enable the zoophytologist to study the species from the successive coralliferous series of Sind and their relation to the coral-faunas from presumed similar geological horizons in Europe, Java, Australia, and the West Indies. J. M.

POST-GLACIAL.

Sir,—In your August Number, my friend and colleague Mr. H. B. Woodward reasserts that *Elephas antiquus*, *E. primigenius*, etc., are not known from beds whose age is certainly Post-Glacial.

Regarding the valley of the Thames as entirely posterior to the latest trace of glacial conditions in Britain, I must regard the lower terraces, which contain the fauna in question, as very late Post-Glacial deposits, and I think that some of those in the Colchester district, certainly that at Lexden, are still more recent.

But leaving the Thames valley out of the question, the Colne valley and the Lexden deposit therein settle the age of the fauna we have to deal with. The country consists of London Clay, with a thin irregular coating of gravel (Middle Glacial) and an upper coating of the Chalky Boulder Clay, to which formation none who have duly examined it assign other than a marine origin. The Colne valley cuts through the Glacial beds into the London Clay, and its bottom is occupied, as usual, with alluvial meadows. A few feet above the alluvium, there occur at intervals, on either side of the valley, remnants of older alluvial terraces, consisting, like the modern ones, of gravel, loam, peat, etc.

That at Lexden, at not more than 40 feet above the present river-bed, furnished remains of the two Elephants named above, and of insects indicating a warmer climate than the present. The Chalky Boulder Clay is to my mind the last scene of the Glacial Period in Britain, the Hessle Clay being, so to speak, the last speech in that scene, so that the Colne valley is wholly Post-Glacial, still more so its deposits. Palæolithic Man lived on its slopes and doubtless slew the deer and other game, whilst the *burnt stone* found in the Lexden brickearth seems to indicate that an ancestor of the immortal Soyer was in the neighbourhood when *Elephas primigenius*, approaching his favourite drinking place in the swamps of the Colne, incautiously "put his foot in it," and remained, till Mr. Fisher found him, a *standing* warning to those who are insufficiently acquainted with the nature of Post-Glacial deposits to confine themselves to more solid ground.

W. H. Dalton.

25, Portland Street, Newark.

An Anonymous Correspondent has fowarded us the following List of papers *not read* at the British Association, Swansea.

Ramsay. On the Occurrence of masses of baked pudding-stone in an old Lake-Basin.
Pengelly. Discovery of Punfield Beds in another Cavern near Torquay.
Whitaker. The Perfection of the Geological Record.
Dawkins. Early Man in French beds.
Lee. Another Cove with fishes in the Old Red Sandstone.
Percy. The Use of the Divining Rod on the Geological Survey.
Barrett. Spirit-levelling: its application in a geological section.
Hull and *Kinahan.* On Faults and Disturbances in Ireland.
Hicks. A Lode on Saddle-back.
Croll. Bi-Cycles and Geological Time.
Burnaby. The Distribution of the Cockle in past times.
Taylor. Half-hour's knapping in a Chalk-pit.

Erratum.—Geol. Mag. for July, 1880, page 301, line 2, for *Port Dinorwic* read *Carnarvon.*

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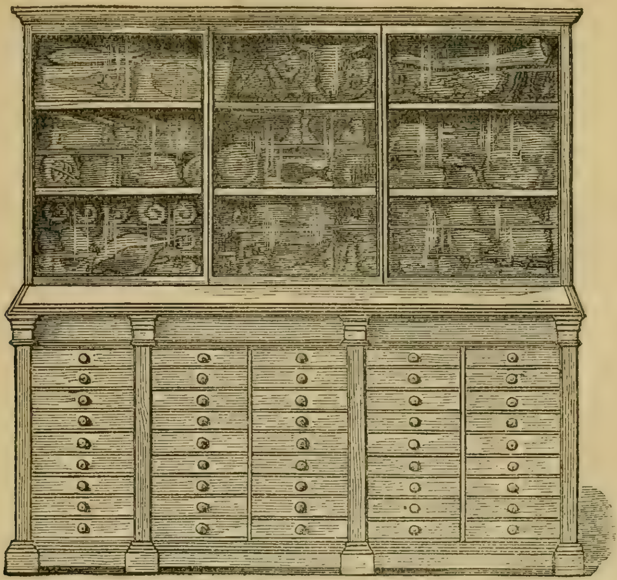

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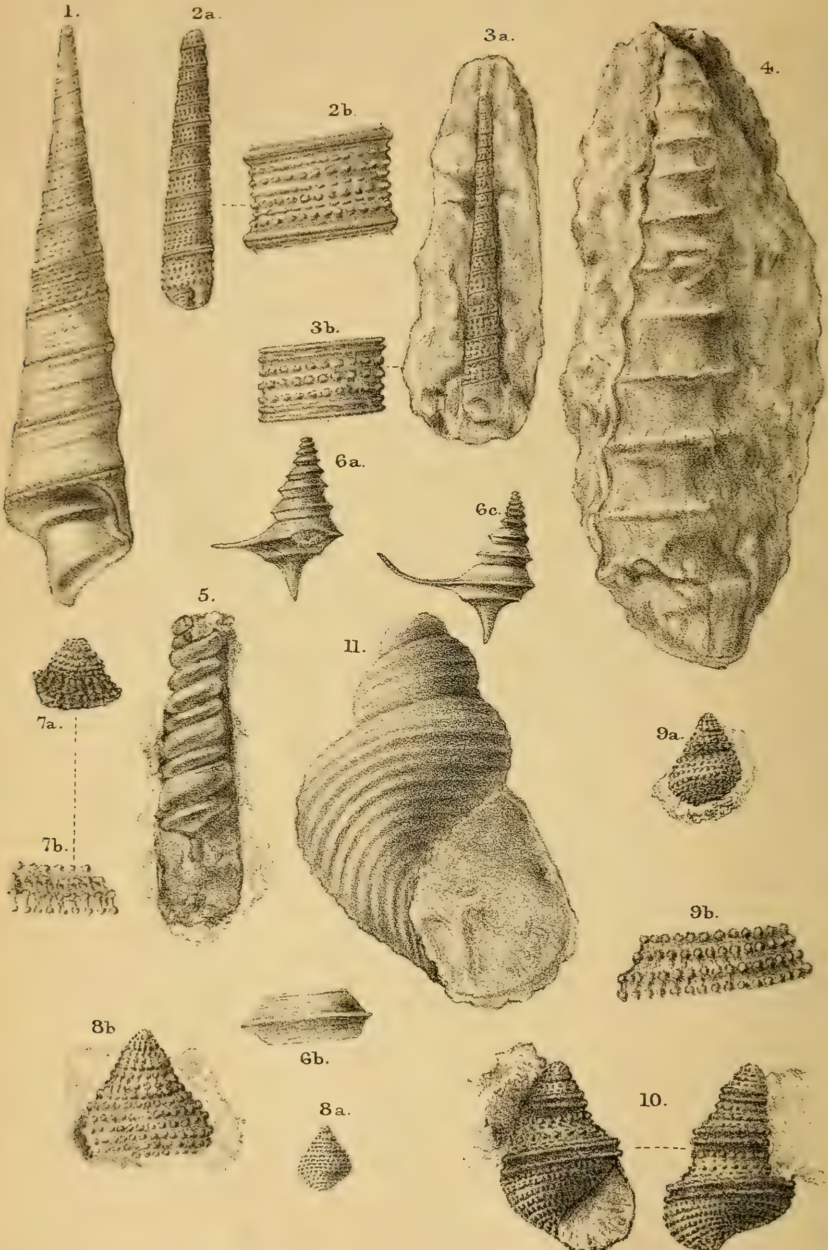

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VII.

No. XII.—DECEMBER, 1880.

ORIGINAL ARTICLES.

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

PART V.

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

(PLATE XVII.)

28.—Nerinæa pseudovisurgis, sp.n. Pl. XVII. Fig. 1.

Description.—Specimen from the Coralline Oolite of Pickering (Leckenby Collection).

Length (full)	83 millimètres.
Width (full)	17 ,,
Length of last whorl to entire shell	23 : 100
Spiral angle	14°.

Shell moderately elongate, conical, solid. Spire formed of an angle very nearly regular. The whorls are numerous and of moderate height. The posterior whorls in this specimen have suffered from abrasion. They are nearly flat, and the ornaments were apparently similar to those in the central part of the shell. The ornaments on the anterior whorls, if ever they existed, are for the most part obliterated, but the nodular character of the rim at the base of each whorl is still shown; these whorls are moderately excavated. The ornaments on the portions preserved in the centre are as follows. Each whorl is slightly depressed in the middle, and closely fitted on to the next by a raised nodular rim: that rim which is at the base of each whorl is by far the most nodular. Five transverse rows of granulations, the three centre ones being the strongest, fill up the space between the rims.

The outer lip is broken away posteriorly, but the general shape of the aperture is trapezoidal to quadrate, with a considerable prolongation of the canal anteriorly.

Relations and Distribution.—It is quite clear that this species is pretty near to *N. visurgis*. The chief differences are—*firstly*, this form is more elongate. The spiral angle in Rœmer's figure of *N. visurgis* is 19°, and D'Orbigny gives it as 20°. *Secondly*, ours is a more highly ornamented shell: Rœmer's description is not very close, but his figure only shows two rows of transverse granulations in the middle portion of the whorl. It may be convenient to lump all these shells under the general title of *N. visurgis*, including even such stumpy forms as *N. castor*, but, whatever names we give, such marked differences should at least be pointed out. Still if we must seek for the nearest foreign relations of the Yorkshire *Nerinæa*, I

[1] Continued from the November Number, p. 488.

should prefer *N. speciosa*, Voltz, as identified by D'Orbigny (Terr. Jurass. vol. ii. p. 123, pl. 269, figs. 1 and 2), or *N. cæcilia*, D'Orbigny (vol. ii. p. 131, pl. 272, figs. 1–4). The general outline and angular measurements of these species—especially of the latter, which only differs in some details of ornament—are far nearer to those of our shell than are the dimensions of Rœmer's species, with which it has hitherto been identified.

We ought to bear in mind that the base of the Coralline Oolite of Pickering, where *N. pseudovisurgis* most frequently occurs, belongs to beds which, in France, would be classed as Oxfordian. It also occurs towards the top of the Coralline Oolite at Ayton and Seamer, where there is perhaps another, though somewhat similar species. Less frequent in the Howardian Hills. Often associated with *Chemnitzia Heddingtonensis*. The cast (Pl. XVII. Fig. 5) may represent an internal mould of this species.

29.—Nerinæa Rœmeri, Philippi, 1837. Plate XVII. Figs. 2*a*, *b*.

Nerinæa fasciata, in Rœmer's Ool. Geb. 1836, p. 144, pl. xi. fig. 31.
Nerinæa Rœmeri, Philippi, Neues Jahrb. 1837, p. 294, pl. iii. figs. 1 and 2; Goldfuss, Petrefac. Tab. 176, fig. 5.

Bibliography, etc.—The *Nerinæa fasciata* of Voltz (Neues Jahrb. 1836, p. 542, pl. vi. fig. 21) is supposed to be different from Rœmer's *N. fasciata*, as quoted in the Nordd. Ool. Gebirges. Brauns (Obere Jura, p. 208) reunites them. The Yorkshire shell in question tallies with Goldfuss's figure, but the form is abundant, and doubtless slight variations have been productive of many names. D'Orbigny's representation of *N. fasciata*, Voltz (Terr. Jurass. vol. ii. p. 121, pl. 268, figs. 3 and 4), is not at all like the Yorkshire species now under consideration. The figure in D'Orbigny which most resembles elongate specimens of the Yorkshire species is *N. Allica* (*op. cit.* p. 98, pl. 255) from the Oolitic Limestone of the Upper Oxfordian, Trouville. This is probably Bean's "allongiuscula" in part.

Description.—Fragment from the Corallian of Yorkshire, with ornaments well preserved. Matrix oolitic. (Leckenby Collection.)

Spiral angle about 6°. Shell narrow, cylindrical. The whorls fit closely to each other, and are but little depressed in the centre. The bounding rim of each whorl is slightly raised so as to produce a salient belt, devoid of tuberculation. Within this space are six transverse costæ. The second, fourth, and sixth of these rows are the strongest, and most tuberculated: the first and fifth are little more than faint lines.

Relations and Distribution.—The species referred as above, *or something very like it*, is by far the most widely spread and abundant of this genus in the Corallian rocks of Yorkshire, ranging as it does from the Oolite of the Lower Limestones (see generalized scheme, pp. 246, 247) through the whole of the Coralline Oolite into the Coral Rag. Thus it is both Oxfordian and Corallian. The following remarks of D'Orbigny, with reference to his *Nerinæa Allica*, may be quoted.

"J'avais d'abord pensé que cette espèce était identique au *N. Rœmeri*, Philippi (*N. fasciata*, Rœmer, non Voltz), mais j'ai reconnu que ce sont deux espèces distinctes, la nôtre ayant 6 côtes toutes tuberculeuses, tandis que le *N. Rœmeri* a des côtes alternativement tuberculeuses et simple." This is driving matters very close indeed. D'Orbigny gives the *opening* of the spiral angle at 3°.

30.—Nerinæa, sp. Plate XVII. Figs. 3*a*, *b*.

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

Spiral angle, average about 5°. Shell extremely elongated, cylindrical. The average angle to be deduced from the imperfect specimen is about 5°, but was probably less towards the apex. The bounding rim of each whorl is scarcely at all raised (Fig. 3*b*), and is devoid of tuberculations: the suture is tolerably distinct. Within the space inclosed between the upper and lower flattened rim are three rows of granulated costæ, of which the middle one is slightly the strongest.

Relations and Distribution.—Not much can be made out of such a fragment by way of accurate comparison. The nearest figured form is *N. subtricincta*, D'Orbigny (Terr. Jurass. vol. ii. p. 130, pl. 271, figs. 8–10). The dimensions agree pretty well, but in the French specimen the upper and lower edges or rims of the whorl are tuberculated.

It is by far the longest and narrowest of the Yorkshire Nerinæas, and ill-preserved fragments, showing it to have attained a great length, are to be met with in the Coral Rag of the Howardians. It may in part be the "allongiuscula" of Bean, but whatever the designation it is a totally different species from the one described as *N. Rœmeri* (Plate XVII. Fig. 2).

31.—Nerinæa Goodhallii, Sowerby, 1836. Plate XVII. Fig. 4.

Nerinæa Goodhallii, Sowerby in Fitton, G. T. 2 ser. vol. iv. p. 348, tab. 23, fig. 12.

Bibliography, etc.—Sowerby's specimen was from the Corallian of Weymouth, where it is one of the characteristic fossils of the *Trigonia*-beds. The average spiral angle of his figure is 10°. His description is very brief: "Turrited, smooth; whorls numerous, half as long as they are wide, concave. There are three plaits in the interior, one upon the columella, one opposite to it, and one above within the whorl: aperture rhomboidal."

Description.—Specimen from the Coral Rag of Yorkshire (Collection of the Yorkshire Philosophical Society).

Length, estimated	135 millimètres.
Greatest width	19 ,,
Spiral angle, average	10°.

Shell elongated, conical, turrited. The portion of the spire preserved is composed of whorls which increase under a regular angle of 10°. They are much excavated, and proportionately raised at either margin. On the posterior margin there is no decided rim, but the anterior margin of each whorl developes a very strong rim, which displays a moderate degree of tuberculation (a little worn away perhaps). Otherwise the whorls are without ornament, beyond an appearance of fine transverse striation, in that portion of the spire which remains. Suture very close and rather oblique. The aperture is imperfectly shown.

Relations and Distribution.—The representative species in France is *N. Defrancii*, D'Orb. (Terr. Jurass. vol. ii. p. 108, pl. 262, figs. 1 and 2), but that is a wider shell, having a spiral angle of 15°. It is stated to be the most common of Corallian age in that country. A nearer relative is *N. tuberculosa*, Rœmer (Ool. Geb. p. 144, tab. xi. fig. 29), which occurs, according to Brauns (Obere Jura, p. 206), in the Lower and Middle Kimmeridge of North-west Germany. It would hardly do to aver that *N. Goodhallii* and *N. tuberculosa* are synonyms, but the Yorkshire specimen under consideration has points of resemblance with each, and, if less worn specimens could be procured with a stronger tuberculation, the resemblance to Rœmer's species would be still more striking.

The species is very rare in Yorkshire. The only other specimen known to me was formerly in the cabinet of a Malton collector. Both probably came from the Coral Rag of the Howardians.

Genus Alaria, Morris and Lycett, 1850.

This genus, so characteristic of the Mesozoic rocks, is very poorly represented in the Yorkshire Corallian. One well-known and widely-spread form is moderately plentiful in the lower beds. This is the essentially Oxfordian species *Alaria bispinosa*, Phillips.

A few ill-preserved specimens of one or two other species have been obtained from the Coral Rag, but neither in public museums nor in private collections is there anything which it would be safe to name or interesting to figure. In the South of England the Corallian rocks are somewhat richer in this respect.

32.—Alaria bispinosa, Phillips, 1829. Plate XVII. Figs. 6*a*, *b*, *c*.

Rostellaria bispinosa, Phillips, Geology of Yorkshire, 1829, tab. iv. fig. 32. ? tab. vi. fig. 13.
Pterocera Cassiope, D'Orbigny, 1847, Prod. de Pal. Strat. vol. i. p. 356.
Alaria Cassiope, D'Orbigny, Continuation de la Pal. Franç. (Piette), 1re sèrie, p. 154, pl. xxiv. figs. 1-4.

Bibliography, etc.—The original figure by Phillips is characteristic, but being unaccompanied by description, has left room for doubt, more especially since the author gave the same name to a similar fossil found in the Kelloway Rock of Scarborough. D'Orbigny calls this latter *Pt. armigera*. It is figured, etc., in the Continuation de la Pal. Franç. (p. 110, pl. 22, figs. 1–6) as *Alaria cochleata*, Quenst. The author (p. 113) states that it is closely allied to *Alaria trifida*, Phil., and further observes that "we cannot conceal from ourselves that these different fossils belong to an identical type which is perpetuated throughout the ages, receiving at each epoch corresponding to a stage some very slight modifications."

No words could describe the true state of things more accurately than these, and they go to show the unequal value of specific names in such a case as that of *Alaria bispinosa*—a common form, first noticed by Phillips in the Lower Calcareous Grit of Yorkshire, but which may be found with more or less modification in other formations of the Jurassic period.

Description (Figs. 6*a*, *b*).—Specimen in a hard blue gritty limestone, said to be from the "Coral Rag" of Pickering, but more probably from one of the blue beds of the Lower or Middle Calcareous Grit of that locality (Jermyn St. Museum).

Length, excluding canal	18 millimètres.
Width of last whorl without wing	9 ,,
Spiral angle	32°.

Shell moderately elongated, strongly turrited. Spire composed of about ten whorls (apex broken off). The whorls posterior to the penultimate increase under a pretty regular angle, averaging 32°, and present a well-marked keel towards the lower third. The penultimate increases rather suddenly and with a proportionate development of keel. The body-whorl still further increases and developes a very strong keel or varix, to which a second or anterior keel is subordinate. These probably support a two-fingered wing, which itself, together with the aperture, is concealed in matrix.

The ornaments on the whorls consist of very fine transverse lines (Fig. 6*b*), in some cases slightly granulated. This kind of ornament, only noticeable in a well-preserved specimen, pervades the entire shell, and slightly decussates with faint lines of growth. The principal keel is a little fretted.

Fig. 6*c*.—Specimen from the Lower Calcareous Grit of Cayton Bay (Leckenby Collection). As regards the fine striations this is in an inferior state of preservation. The anterior keel of the body-whorl is perhaps a little stronger than in the other specimen.

Relations and Distribution.—The relations of this species have already been partially indicated. Piette observes (*op. cit.* p. 155) that it is distinguished from others of the same genus by the prominence of the keels. In France, its head-quarters are in the "oolithe ferrugineuse," at Neuvisy, Viel-Saint-Remy, etc. In Germany *Chenopus bispinosus*, Phil., is quoted by Brauns (*Ob. Jura*, p. 185), from the Heersumer Schichten (*perarmatus*-zone) of N.W. Germany.

In Yorkshire *A. bispinosa* occurs throughout the Lower Calcareous Grit, and seems to have been found at Pickering in beds which may possibly be as high as the *Trigonia*-beds at the base of the Coralline Oolite. I have never seen a specimen from the Coral Rag.

Postscript.—There is a good specimen amongst the Kelloway Rock fossils in the Museum at York. The spiral angle is slightly closer. There is a less sudden increase in the penultimate whorl, whilst the keel is a little more towards the middle: the anterior keel of the body-whorl is rather stronger than in the Lower Calcareous Grit fossil. The ornamentation is similar, and the differences are exceedingly slight.

Family Littorinidæ.

The shells next to be described were formerly referred to *Turbo*, though at present it is customary to regard them as belonging to *Littorina*—an arrangement which is perhaps provisional. De Loriol and Pellat restore to this class of shell the generic name of *Turbo*, though the reasons adduced by Deslongchamps[1] for excluding at least a part of them from the family *Turbinidæ* remain as good as ever.

The same difficulty, encountered in dealing with *Cerithium limæforme*, meets us in describing the three distinct forms which are usually classed in collections under the heading *L. muricata*, Sow. Perhaps the Yorkshire specimens are not exactly similar to the species with which they have been correlated. Sowerby himself was prepared for a division of *L. muricata*, since he observes that there are three species which have been confounded together, but which he hopes hereafter to show are quite distinct.

33.—Littorina muricata, Sowerby, 1821. Pl. XVII. Figs. 7, 8, 9.

Turbo muricatus, Sowerby, 1821, Min. Conch. vol. iii. p. 70, pl. 240.

Bibliography, etc.—Sowerby refers to the table in Smith's Strata entitled "Coral Rag and Pisolite," where there is a good figure. The specimen figured by Sowerby came, we may infer, from Steeple Ashton, and has a general resemblance to Fig. 9*a*. He describes it as very pointed, and nearly as wide as long: the ornaments are described in very general terms. The plaited lip and indentation of the columella are given as essential characters.

A.—Variety sometimes referred to Littorina Meriani, Goldfuss, 1844.

Turbo Meriani, Goldfuss, 1844, Petref. vol. iii. p. 97, pl. 193, fig. 16.
Idem, D'Orbigny, 1850, Terr. Jurass. p. 355, pl. 335, figs. 1—5.

Bibliography, etc. — This is a regular Oxfordian form, and D'Orbigny fancied it might be the same as Phillips's *Turbo sulcostomus*. His figure and description refers to a larger shell than ours. The proportions are about the same, and he allows considerable latitude for the ornaments.

Description (Fig. 7*a*).—Specimen from the Lower Calcareous Grit of Scarborough (Leckenby Collection).

Length	14 millimètres.
Width	11 ,,
Spiral angle, average	67°.

Shell rather longer than wide. Spire composed of about six whorls, separated by wide and tolerably deep sutures, which materially affect the contour of the shell. The penultimate whorl has three transverse costæ, very spiny, the lowest one being the strongest and most prominent. The last whorl has four spiny bands in the posterior portion: of these the two middle ones form a slightly raised belt round the shell. The base of the whorl and the aperture are concealed.

Fig. 7*b* represents an enlargment of the upper part of the last whorl.

[1] Bull. Soc. Linn. Norm. 1860, Note sur le genus *Eucyclus*.

Relations and Distribution.—This form has a larger spiral angle than the two succeeding ones, and differs to a certain extent in the character of its ornaments. It occurs chiefly in the Lower Calcareous Grit, and never ascends into the Coral Rag.

B.—Variety of LITTORINA MURICATA, probably the *Turbo muricatulus* of Young and Bird.

Description. Fig. 8*a*.—Specimen from the Coral Rag of Brompton (my Collection).

Length	10 millimètres.
Width	8 ,,
Spiral angle, average	62°.

Shell rather longer than wide, oval, not umbilicated. Spire composed of about five whorls, which increase under an angle nearly regular, and without prominence. Suture rather close. Ornaments on the apical whorls (where visible) consist of three transverse costæ, which are but slightly granulated; these decussate with spiral costæ very oblique to the axis. In the penultimate whorl the transverse costæ are granulated, the granulations being very round and very regular, and a fourth row is partially developed: the spiral costæ become finer and the intervening mesh is striated in the same direction. In the body-whorl there is no further trace of spiral costæ, but the spaces between the rows of granulations are finely striated. These rows are five in number, the third and fourth being very slightly prominent: in the base of the whorl are about five lines of smaller granulations, making ten in all. The aperture is concealed in matrix.

Fig. 8*b*.—Another specimen enlarged.

Relations and Distribution.— This pretty little shell rather reminds one of a beehive. It represents the form of the genus which is most removed from *Eucyclus*. Very characteristic of the Coral Rag of Brompton and Ayton: less frequent in the Coral Rag of the Howardians. A somewhat similar form occurs in the Coral Rag of Wiltshire, but I never saw it in the Corallian of Weymouth.

C.—Variety of LITTORINA MURICATA, inclining towards LITTORINA PULCHERRIMA, Dollfus, 1863. Plate XVII. Figs. 9*a*, 9*b*.

Littorina pulcherrima, Dollfus, 1863, Kim. du Cap de la Heve, p. 46, pl. vi. figs. 3-6.

Bibliography, etc.—Dollfus' shell has the following description. Length 30 mm., width 21 mm., spiral angle (convex) 50°. Shell ovate-oblong, imperforate; spire conical; whorls convex, longitudinally (*i.e.* transversely) 4-costate; ribs unequal, tuberculated or muricated; last whorl 13-costate: aperture roundish.

Dollfus admits that his shell is near to *Turbo Meriani*.

Description. Fig. 9*a*.—Specimen from the Coral Rag of North Grimston (my Collection).

Length	15 millimètres.
Width	10 ,,
Spiral angle, average	56°.

Shell half as long again as wide, oval oblong, not umbilicated. Spire composed of about six whorls, of which the last exhibits considerable prominence; sutures well marked and wide. The whorls have four costæ, of which the two lower form a strong double-ridged varix (affinity with *Eucyclus*). About five costæ, with granulations diminishing in size anteriorly, occupy the base of the last whorl, making nine in all. The further details of the ornamentation correspond with those of *L. muricatulus.*

Fig. 9*b.* represents the upper portion of the last whorl of a specimen from the *Trigonia*-beds of Weymouth, which approaches still nearer to *L. pulcherrima.*

Relations and Distribution.—The affinities of this shell may be partly gathered from previous descriptions. Regarded in a general way it may be viewed as a Corallian or Kimmeridgian variety of an Upper Oxfordian form which is tolerably Protæan in its ornamentation, and perhaps in the vigour of its growth. The "species" (regarding *L. muricata,* Sow., for the moment as one) assumes an infinity of aspects under the influence of physical conditions, and of distance in time and space. The variety just described is perhaps the nearest to the original *L. muricata* of Steeple Ashton, to judge from Sowerby's figure, but with a spiral angle of lower value, and perhaps a more elaborate ornamentation. In Yorkshire it is chiefly found in the Coral Rag of the Howardians.

In North Germany the group is probably represented in part by *Turbo punctato-sulcatus,* Rœmer (Ool. Geb. pl. xi. fig. 7, p. 153), which, according to Brauns (Ob. Jura, p. 222), occurs sparingly in the Coralline Oolite of Hoheneggelsen and Hildesheim.

Subgenus Amberleya, Lycett, 1850 = *Eucyclus,* Deslongchamps.

The subgenus *Amberleya* was first instituted by Lycett (Morris and Lycett, Great Ool. Moll. p. 54), in 1850 for a section of *Littorina,* agreeing in general characters with the genus *Pagodus* of Gray. The generic definition was not very close. Only one species was described, and that not very characteristic. In 1860, Deslongchamps (*op. cit.* p. 138) wrote a valuable note showing the utility of withdrawing from the genera *Turbo* and *Purpurina* certain shells of the Jurassic formations, for which he proposed to institute the genus *Eucyclus.* This he admits to be the same as the *Amberleya* of Lycett, but he gives a much fuller diagnosis, and describes some new species. In 1863, Lycett (Suppl. to Great Ool. Moll. p. 19) alludes to the importance of Deslongchamps' work, and shows that *Eucyclus* is a synonym of *Amberleya.*

34.—Amberleya Stricklandi, sp.n. Plate XVII. Fig. 10.

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

Length	23 millimètres.
Width across the belt	16 ,,
Spiral angle, average	57°.

Shell nearly half as long again as wide, ovate oblong, not umbilicated. Spire composed of five or six whorls; the two anterior very large and angular, whilst the sutures are strongly pronounced. The body-whorl is inflated, and exceeds in height the rest of the spire.

A very distinctive feature consists in a prominent double varix on each whorl, which is rather less tuberculated than the other costæ (possibly from the effects of wear). On the penultimate whorl are seven costæ in all. The highest row has the largest and best cut tuberculations, the second and seventh are the faintest, the fifth and sixth form the prominence. The same number and arrangement are observed on the posterior portion of the last whorl, the base of which has ten rows of fine granulations nearly equal in strength, and curving round the columellar area towards the anterior extremity. Shell substance thin. Aperture wide and generally roundish, coming to a blunt point posteriorly. But little callosity on the columella, which is short and hollowed out.

Relations and Distribution.—Although this handsome species has affinities with the group previously described, by far its nearest relation is *Amberleya armigera*, Lycett (Suppl. to Great Ool. Moll. p. 20, pl. 31, fig. 6), a fossil of the Yorkshire Cornbrash. The general outline of these two species is almost identical, but the Corallian shell is more highly ornamented, and the costæ in the base of the body-whorl are finer and more numerous. It may justly be regarded as the representative of the Cornbrash species on a higher horizon.

The shell in question is very rare, but Sir Charles Strickland has found a few of them, chiefly in the Coral Rag of the Scarborough district (Seamer, Ayton, Brompton). No specific name could be more appropriate than that of its discoverer.

It should be observed that imperfect specimens resembling "*Turbo*" *Buvignieri*, D'Orb. (Terr. Jurass. vol. ii. p. 256, figs. 6–8) have been found in the Coral Rag of Ayton.

35.—Amberleya princeps, Rœmer, 1836. Plate XVII. Fig. 11.

Turbo princeps, Rœmer, Ool. Geb. 1836, p. 153. pl. xi. fig. i.
Idem, D'Orb., 1850, Terr. Jurass. vol. ii. p. 357, pl. 335, figs. 9, 10.

Bibliography, etc.—This species is so well marked that authors have had little difficulty in recognizing Rœmer's figure and diagnosis.

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

Length	61 millimètres.
Width	32 ,,
Spiral angle	56°.

Shell oval oblong, not umbilicated. Spire composed of about five very convex whorls, separated by wide sutures. The ornaments in the specimen are a little indistinct, the salience of the ribs being very much reduced. The fine oblique striation between the ribs is not visible. A pair of more prominent ribs is noticeable in the anterior portion of each whorl. Shell substance very thin. The outer lip is straight and protracted, turning suddenly towards the anterior margin, which is squarish: columella much excavated. Aperture large in every direction.

Relations and Distribution.—D'Orbigny's figure represents a more oval mouth, but there can be very little doubt as to the identification. The ancestors of this handsome species must, I suppose, be sought amongst the numerous representatives of *Amberleya* in the Lower Oolites. This is essentially a Corallian form occurring, according to Rœmer, in the Upper Coral Rag of Hildesheim. Brauns (Obere Jura, p. 221) describes it as a "leit fossil," of the middle beds of the Coralline Oolite in Hanover, etc. D'Orbigny had it from the East of France and from La Rochelle.

In Yorkshire it is very rare, and has only been found in the Coral Rag of the Howardians. It occurs at Upware, but is unknown to me from any other part of England.

EXPLANATION OF PLATE XVII.

FIG. 1. *Nerinæa pseudovisurgis*, sp.n. Coralline Oolite of Pickering. Leckenby Collection.
,, 2*a*. *N. Rœmeri*, Philippi. Corallian of Yorkshire. Leckenby Collection.
,, 2*b*. The same, whorl enlarged.
,, 3*a*. *Nerinæa*, elongated species. Coral Rag of Langton Wold. My Collection.
,, 3*b*. The same, whorl enlarged.
,, 4. *N. Goodhallii*, Sow. Coral Rag of Yorkshire. York Museum.
,, 5. *Nerinæa*, cast of part of interior. Coralline Oolite of Pickering. My Collection.
,, 6*a*. *Alaria bispinosa*, Phillips. Possibly from the *Trigonia*-beds of Pickering. Jermyn Street Museum.
,, 6*b*. The same, portion enlarged.
,, 6*c*. *Alaria bispinosa*, another specimen. Lower Calcareous Grit of Cayton Bay. Leckenby Collection.
,, 7*a*. & *b*. *Littorina*, cf. *Meriani*, Goldf. Lower Calcareous Grit, Scarborough. Leckenby Collection.
,, 8*a*. *L. muricata*, Sowerby, var. *muricatula*, Young and Bird. Coral Rag of Brompton. My Collection.
,, 8*b*. Another specimen enlarged.
,, 9*a*. *Littorina*, cf. *pulcherrima*, Dollfus, pars. Coral Rag of North Grimston. My Collection.
,, 9*b*. Portion of a specimen from the *Trigonia*-beds at Weymouth, enlarged.
,, 10. *Amberleya Stricklandi*. Coral Rag of Brompton. Strickland Collection. Front and back.
,, 11. *Amberleya princeps*, Rœmer. Coral Rag of Hildenley. Strickland Collection.

(*To be continued.*)

II.—On some Serpentines from the Rhætian Alps.

By Prof. T. G. Bonney, M.A., F.R.S., F.G.S.

THE name serpentine has been applied by many authors with so much vagueness that it appears to me desirable to lose no opportunity of examining any rock bearing this title, and to record briefly the result.[1] A considerable number of patches of serpentine, generally of limited extent, are laid down on Ritter von Hauer's Map of the Eastern part of the Alps, some of which also appear on that of Professor Theobald (sheet xx. of the Federal Map of Switzerland). Several of these I was able to examine, sufficiently for my purpose, during a visit to the district last summer.

The first patch of serpentine which I was able to visit *in situ* is

[1] In Prof. Theobald's admirable monograph, Geol. Beschreib. von Graubünden, we find (p. 40), after he has admitted that there is much to favour the view of serpentine being an eruptive rock, the following statement: "Es möge der Serpentin eine letzte Stufe vom Umwandlung anderer Gesteine, Gabbro, Hornblendefels, Diorit, und selbst Schiefergebirgs sein, wie schon Studer bemerkt."

crossed by the Julier road about 500 yards below the village of Rofna (between Tiefenkasten and Molins). The serpentine is a compact, dark purplish-green rock, of characteristic aspect, showing occasional small folia resembling an altered bronzite. The rock is greatly jointed and crushed, with slickensided surfaces, coated with a polished green or waxy-green mineral; so that in part it has almost a schistose aspect, and the true structure can only be seen on a cross fracture. The serpentine is overlain by a reddish to greenish schistose rock. The junction of these is difficult to examine, but the relations of the two suggest that the former is intrusive in the latter. The following is a description of the microscopic structure of this serpentine.

The slide is traversed by irregularly reticulated strings of clotted opacite, obviously following cracks, and deposited on their sides. The interspaces exhibit a fibrous border, dull bluish white with crossing Nicols; the "eyes," or more granular centres, being often dark with crossed Nicols; in short, all the structures characteristic of an altered olivine rock. Scattered in this ground-mass are small plates of irregular outline, now of a serpentinous character, but still showing one close, rather wavy, parallel cleavage, and traces of another, much less distinct, and inclined to it at a considerable angle. In this mineral we need not hesitate to recognize an altered bronzite, or, perhaps, rather enstatite, as it is wholly, or almost wholly, free from opacite. Probably much of the opacite in the rest of the slide is magnetite, but the grains are not very definite in outline. Two or three very dark-brown grains may be picotite or chromite, and there is a flake or two of ironglance. There can be no doubt this serpentine is an altered olivine-enstatite rock.

In the lower part of the Val da Faller, which joins the Oberhalbstein Rhine at Molins, are four dyke-like masses of serpentine. Debris or turf generally just mask the actual junctions, but there can be no doubt that they are intrusive in the green schist, as they cut (in one case very clearly) across the bedding. The two rocks are quite distinct in character. The description given above will apply in general terms here,—these serpentines having the same shattered slickensided character, so that it is most difficult to obtain even tolerable specimens. Fragments from two of the masses have been examined microscopically. It is needless to describe them in detail. They have undoubtedly been olivine-enstatite rocks, though now perhaps a little more altered than the last. The schist, a distinctly bedded rock of pale-green colour, compact and slightly earthy in aspect, is seen under the microscope to consist of a minute granular kaolin-like mineral, interspersed thickly with flakes of a rather fibrous, almost colourless mineral (probably uniaxial, and one of the chlorite group), with much ferrite and some viridite. A little felspar is recognizable in nests. At the first glance it seems dubious whether the rock should be classed with the true schists, but closer study leads me to the conclusion that, though very minute, the constituents are mainly of secondary origin.

About 450 feet above Molins, the road and river cross another mass of dark-green serpentine. Here, also, the relations of the serpentine with the schist are almost inexplicable, except on a theory of intrusion—as may be seen on the (inaccessible) left bank of the stream. The macroscopic character of the serpentine is very similar to that of the rocks already mentioned. Microscopic examination shows it to be an altered olivine-enstatite rock, each mineral occurring in rather more distinct grains than usual, and, as we may infer from the greater abundance of opacite in both, rather richer in iron than in the other cases. The schist, in a gorge immediately above, is much contorted, and its surface is glaciated. Under the microscope it is seen to consist of grains of a yellowish epidote, flakes apparently of a clear mica, microlithic rods of an iron oxide, and a clear mineral, which is for the most part more probably felspar than quartz, all very minute. There is but little appearance of separation into distinct mineral layers, and the rock has not a very highly altered aspect; still I believe these minerals to be all of secondary formation.

On approaching the village of Marmels, an extensive mass of serpentine is seen to occur in the hill-side on the right bank of the valley, and, at the entrance of the village, the road passes through a cutting. The rock here is an ophicalcite, rather schistose-looking, but really only a crushed serpentine, cemented by subsequent infiltration. The principal mass of serpentine, judging from blocks by the road-side, is of the usual character. Some distance above the village this rock is crossed by the road. Here is also a considerable mass of gabbro. This varies from very coarse (diallage crystals up to nearly half-inch diameter) to rather fine, and it exhibits occasionally a slightly schistose structure—a character not rare near the exterior of gabbro masses. It can be seen by the road-side cutting through the serpentine. The last rock differs a little from those previously described, being an altered olivine-augite-enstatite rock. The first of these minerals is, as usual, changed into serpentine; the last is more or less serpentinized, but the second generally is in good preservation. There are two or three grains resembling enstatite in form, but wholly replaced by iron oxide.[1]

Two specimens of the gabbro have been examined microscopically. One, of the coarser variety, was taken from a block, recently broken by blasting, in an old moraine a little lower down in the valley—but undoubtedly from some part of the mass (the specimens seen *in sitû* not being in good condition); the other, finer, was obtained from the mass which cuts through the serpentine. The former con-

[1] The following analysis is given by Prof. Theobald of a serpentine from Marmels:

SiO_2	=	38·88
Al_2O_3	=	4·67
MgO	=	36·41
$FeO.Fe_2O_3$	=	8·63
H_2O	=	11·37
		99·96

As there is no CaO in the analysis, probably the specimen did not contain augite, but had some spinel.

sists of a felspar—generally so much kaolinized, or replaced by secondary microlithic minerals, as to have lost its characteristic aspect, and to be a kind of "saussurite," but here and there retaining traces of plagioclastic twinning—and of fairly well preserved diallage. The felspathic constituent has the granular outline common in gabbro, and has probably been labradorite. A crack is filled with a chloritic mineral. The pyroxenic constituent of the finer variety is augite, and there are grains of a fibrous serpentinous mineral, which also fills cracks and appears to be disseminated in the slide.

Rather higher up the valley, on the right bank of a grassy basin, near some chalets (Stalvedro), is a small excavation in a band of hard crystalline limestone beneath a shivery mica schist, on the eastern side of which is a shattered serpentine underlying a greenish schist, its mode of occurrence suggesting intrusion. The limestone under the microscope appears to be more strictly a dolomite, with minute quartz grains (of secondary origin) interspersed, in parts rather thickly, and traversed by cracks filled with the latter mineral. Above this spot there is no more serpentine on the Julier pass, but two patches are laid down on the ascent to the Septimer, which diverges at Bivio Stella.

Following roughly the directions indicated by the above sporadic exposures—towards the S.E.—we find another mass of serpentine on the northern side of the Maloya Pass. It forms a headland on the left bank of the Silser See, and extends for some distance up the mountain side. This rock agrees generally in colour with the last named, but is less crushed than is usual with the others, and exhibits the brown weathering, massive structure, and sharp, rather irregular jointing so characteristic of true serpentines. Microscopically it has a general resemblance to the rock from above Marmels, as it contains both enstatite and augite. The former is much altered, the latter (of irregular outline) in fair preservation; one grain appears to be diallage; most of the others resemble normal augite; none of the olivine has escaped quite unaltered, but in parts of the slide the change seems less complete than is the case in the other serpentines. In this slide also are visible some of the black grains described above. The last two serpentines then may be roughly classed as altered lherzolites; and all are altered peridotites.

A considerable number of patches of serpentine appear on Von Hauer's map about the head of the Schalfik-Thal and Landquart-Thal. From them probably were derived several pebbles which I saw near Chur; these corresponded in general appearance with the specimens already described.

It is impossible to offer an opinion as to the geologic age of these peridotites. From their shattered condition it is in the highest degree probable that they have partaken of some, if not all of the great movements which have affected the Alps, and so are at least older than the Middle Tertiary period. They are mapped as intrusive in Bundner Schiefer, which, according to Von Hauer and Theobald, belong to the Lower Lias. The latter, however, considers some of the schist near Molins to be of much earlier date, and I confess I cannot see the reason for separating the one from the other. All those which I found associated with serpentine appeared to be much more highly altered than would be likely in rocks of this age. Indeed, the condition of the admittedly Triassic rocks of the Engadine justifies us in assigning to all these schists a much greater antiquity than any part of the Mesozoic period. With our present knowledge extreme caution is doubtless required in drawing an inference as to the age of a rock from its state of metamorphism. At the same time all the evidence which we possess points to the conclusion that extensive regional metamorphism has only taken place in rocks of great geological age, and that the current statements about highly altered Secondary and even Tertiary rocks in the Alps are in many cases certainly erroneous, and in all need confirmation. Thus, in the case of these Alpine schists, which as a rule are more highly altered than any rock in Britain known to be of Cambrian or Post-Cambrian age, I should agree with some of the more modern Continental geologists in regarding them as very old and possibly Pre-Cambrian. While then we may be quite certain of the origin of these serpentines, we have very wide possible limits for their geologic age.

III.—Notes on the Occurrence of Stone Implements in the Coast Laterite, South of Madras, and in High-level Gravels and other Formations in the South Mahratta Country.[1]

By R. Bruce Foote, F.G.S., Geological Survey of India.

In June, 1868, I had the honour to read before the Geological Society of London a paper on the occurrence of Chipped Stone Implements in beds of conglomerate and in various non-compacted gravels belonging to the Lateritic Series, which fringes the greater part of the Peninsula of India. The district within which implements had then been discovered in the coast laterite extended from the Pálár river near Madras, nearly up to the Kistna river, but none from the country south of the former river, though it was surveyed as far south as 12° 15′′ subsequently to the discovery of the implements at Pálávâram and Attrampakkam. Since then it has fallen to my lot to run over part of the lateritic beds north and south of the Cauvery delta, and I had the good fortune to find palæolithic implements at several places in the Trichinopoly, Tanjore and Madura districts.

The lateritic formations of the south, like those occurring further north, form a widely-spread but thin series of conglomerates, gravels and sands, divided by the existing rivers into a number of irregular patches overlying the older rocks, whether gneissic, Cretaceous or Tertiary, and dipping themselves under the marine and fluviatile alluvia which fringe the coast. They have been extensively denuded, particularly along their western boundary; outliers of them being traceable many miles to the west of the present boundary.

[1] This paper has, since the original was read at the British Association, Swansea, been in part re-written, and some additional matter of interest has been added to it.

In the paper just referred to I gave also an account of similar implements found by myself and others, associated with similar more or less lateritic gravels lying at far higher levels and much further inland than any part of the coast laterite series, and I can now add considerably to the list of localities where such high-level implement-bearing beds occur.

The best substitute for flint occurring in Southern India is fine-grained quartzite, of which material an unlimited supply was easily obtainable in the regions round about and to the northward of Madras; and implements made of this stone are in many places to be found in very considerable numbers on the surface of the lateritic beds, from which they have been weathered out. To the south of the Pálár river, however, no quartzite is to be found *in situ*, and as derivative shingle it is of great rarity, and, as was to be expected, the implements were found to be made of other materials, and to occur in very small numbers. As in the more northerly implement beds formerly described, the presence of the implements themselves constitutes the only evidence, hitherto obtained, of the existence of palæolithic man. No other indications of organic life of any sort or kind were seen in the lateritic bed, though most carefully sought for. A solitary rolled fragment of bone, which Professor Boyd Dawkins considers to be part of a human tibia, was found by me, associated with the typical implement bed at Attrampakkam, near Madras, but I am not quite positive that it was absolutely *in situ*. From the position in which it was situated I judged it to have been exposed by weathering, but it might possibly have been lodged there by a flood.

As the number of implements found in the region south of the Pálár is very small, I will enumerate the localities where I met with them in geographical sequence from north to south.

1. *Ninnyur*, about forty miles N.E. of Trichinopoly. Here I got two implements among the debris of the western edge of the Wodiarpalliam laterite plateau, which there rests on the Upper Cretaceous rocks, so well described by Mr. Henry F. Blanford in the Memoirs of the Geological Survey of India. Of these two implements one, which is of the sharp-pointed type, appears to be made of a form of chert, but is too thickly covered with a ferruginous glaze to admit of positive determination of the component material; the other, which is probably referable to the oval type, but has one end broken off, is made of a pale yellowish-drab cherty rock.

2. *Vallam*, seven miles W.S.W. of Tanjore. On the rising ground about three-quarters of a mile E.S.E. of the old fort I found several large but rather rude flakes, two of which were impacted in the hard lateritic conglomerate, and had to be broken out with a hammer. They are formed of a kind of chert, bearing considerable resemblance to the material of which the second Ninnyur implement is made, and very like also to some remarkable masses of chert of Upper Cretaceous age, which occur in the mottled grits belonging to the Cuddalore series, and are exposed in the moat at the N.E. corner of the old fort at Vallam. Besides the flakes I got also a large chert *thumb-*

scraper, a form which had not been found when I read my papers to the Geological Society of London, and to the Congress for Prehistoric Archæology at Norwich, in 1868, and which, so far as I am aware, has not been described as yet occurring in India. This scraper has been considerably waterworn and rolled.

3. At *Shuragudi*, sixteen miles south of Pudukotai, on the boundary between that native State and the Madura Collectorate, I found what I believe to be of the broad hatchet type. It is very rudely made of coarse granular quartz rock, which occurs in great beds in the gneiss and forms several conspicuous ridges in the country N.E. of Madura. Despite its extreme rudeness this implement shows such manifest marks of design that I cannot help regarding it as being *bona fide* of human workmanship. It occurred in lateritic debris close to the edge of a great spread of typical laterite.

4. At *Madura*, in a coarse lateritic gravel, on high ground about half a mile north of the Vygay river, forming what appears to be an outlier of the regular laterite occurring at no great distance to the east, I found two or three rude implements of the oval type; these were also made of the coarse granular quartz-rock above referred to, great beds of which form the very bold and lofty Allagiri (hill) some miles to the north.

It is not possible to tell, from the appearance of these southern implements, whether they were made like the great majority of those found further to the north, from well-rolled pebbles of large size, or whether they were shaped out of angular fragments of the rock broken off for the purpose.

Besides the implements now described, I obtained three other forms all made of chert that has not yet been found *in situ* in this region. The three forms are a small flake like an arrow-head in shape, a true core, and a singular shaped flake used perhaps both as knife and scraper, but with one of the cutting edges distinctly serrated. This last form was found in a river gravel, younger than the adjacent true laterite, a little to the south of Tripatur in the Madura district. The arrow-head and core were found on the surface some miles to the northward, not among lateritic debris. The core is the first perfect one found by me, and I believe the first that has been found south of Central India.

I may here mention, that during my work in the northern half of the Nellore District (in 1875–77), I came across various previously unknown lateritic beds in the valleys of the Penneru and Maneru (rivers), containing implements of nearly all the more southern, or as I may for brevity call them the Madras types, but beside these also several true scrapers. All these were made of quartzite, and differed from the Madras types only in being generally of ruder workmanship.

The implements obtained from the high-level gravels in the Deccan were all made of quartzite derived from the great quartzite beds of the younger metamorphic series locally termed the Kaládgi series, which is the equivalent of the Kadapa series on the eastern side of the Peninsula. The gravels themselves occur at various levels, some being cut through by existing rivers, others lying far above the present stream beds.

The best examples of the former I found in the banks of the Malprabha and the bed of the Bennihalla, its principal tributary, some forty miles S.W. of the junction of the former river with the Kistna. Here, in beds of coarse quartzite shingle cemented by kankar or calcareous tufa, I found many fine, well-shaped, mostly large-sized implements, all of the Madras types. Some very good implements of large size I obtained from another highly calcareous shingle bed, twenty miles further up the bed of the Malprabha. All these implements had been carried but very small distances, as they show little or no signs of attrition, but they were unaccompanied by the numbers of imperfect specimens, flakes, and chips, which characterize sites of manufacture. The quartzite from which they were made was the same kind as that occurring in the great beds at the base of the Kaládgi series, which are well exposed in the great scarp forming the southern boundary of the Kaládgi basin, which here runs closely parallel with the Malprabha river for a long distance.[1]

The other series of gravels occurring at levels never attained by the highest floods of the existing rivers are to be met with at several places north of the great scarp just mentioned, dotted about over the level parts of the Kaládgi basin. Some of these gravels I am inclined to regard as of lacustrine origin; such, for example, is that at Tolanmutti north of the Ghatprabha river.

The very fine series of implements[2] found in the South Mahratta country was exhibited by me at the Vienna Exhibition in 1873, and attracted much notice; I afterwards presented it to the Indian Museum in Calcutta.

In another formation also, but of very different character from the laterites and gravels hitherto noticed, I was fortunate enough to discover implements when surveying in the South-western Deccan in 1870. This was a great talus of angular and rounded blocks of limestone and trap compacted in parts by a calcareous cement, which occurs along the foot of a line of low hills of shale capped with limestone overlaid by a bed of the Deccan Trap, on the left bank of the Kistna river near Agani (Uguni), some twelve or fifteen miles west of Soorapoor. Here, exposed in rain-gullies cutting into this breccia-conglomerate talus, I found several large and well-shaped implements of the pointed oval type, and remarkable for their being made of compact, hard and rather siliceous limestone. This limestone is the best material for the manufacture of implements to be found in the immediate neighbourhood. These implements I also exhibited at Vienna in 1873, and they are now in the Indian Museum in Calcutta.

The only other chipped implement beside the above, not made of

[1] For a fuller description of these beds see my Memoir on the South Mahratta Country in the Memoirs of the Geol. Survey of India, vol. xii. p. 241.

[2] Together with these I exhibited a small but very interesting series of Neolithic implements from the Salem, Bellary, and Kaladgi districts, which are also now in the Calcutta Museum.

quartzite, that I found in the South Mahratta country was a well-made thin leaf-shaped flake, made of a chert strongly resembling the intertrappean chert rock capping the "One-tree-hill" at Shellugi, to the S. S. E. of Bijapur, which I have described in my Memoir on the South Mahratta Country.

IV.—Analysis of Moa Egg-shell.

By Prof. A. Liversidge, F.C.S., F.G.S., University of Sydney.

Read before the Philosophical Institute of Canterbury, New Zealand, August, 1880.

I AM indebted to the kindness of Dr. Julius von Haast, F.R.S., Director of the Canterbury Museum, New Zealand, for the specimen which is the subject of this note. The little packet of fragments was labelled Moa Hunter, Kitchen Midden Sandhills, near Moa Cave, Point Sumner, New Zealand.

All the fragments appeared to be more or less weathered, and the edges, except where freshly fractured, were smooth and rounded, and their general appearance seemed to indicate that they had been subjected either to the action of blown sand or to that of water charged with carbonic acid gas; both influences may of course have been at work together.

The fragments were all very brittle; the fractured edges plainly showing, without the aid of a lens, the presence of two distinct layers in most of the fragments; the inner or concave layer, *i.e.* the one facing the interior of the shell, having a pale brown colour, the middle portion being quite white, whilst the outer surface of the shell presented a pale tint of brown; judging from the different depths of tints, the varying thicknesses, and appearance, the pieces were apparently fragments of several different shells.

It is unnecessary for me to give any account of the microscopical structure of the shell, since that has been so ably done by Prof. F. W. Hutton, of Canterbury College, New Zealand (*vide* Transactions of the New Zealand Institute, vol. iv. p. 166).

The pores are readily seen to penetrate right through the substance of the shell, on account of the brown-coloured matter which most of them contain; some appear to penetrate only to a certain limited distance; but this is because the direction of the pores is not straight, and a portion of their length is cut off in the section; their apertures are visible on the inside of the shell as well as on the outside; the outer openings, however, are considerably larger and are funnel shape—many of these pores can be seen to pass through from side to side by the unassisted eye.

The middle portions of the egg-shell are shown to be of softer material than the two surfaces, since most of the weathered pieces show a groove running along the edges.

On ignition all the pieces of shell experimented upon blackened, and emitted an ammoniacal odour, thus plainly showing that they had by no means lost the whole of their organic matter, and on dissolving portions in acetic acid flocculent particles of organic matter were left floating in the solution; this organic residue, was collected, and found to be a readily combustible nitrogenous body; under the microscope it presented traces of an organized structure.

A careful qualitative analysis was made of a portion of the shell, and in addition to calcium carbonate, alumina (with traces of iron), phosphoric acid, magnesia, sulphur, potash and soda were found to be present, the latter three were in very small quantity and no estimation of the amounts was attempted.

ANALYSIS.

Moisture driven off at 100° C	·20
Carbonic acid	40·05
Phosphate of alumina with traces of iron	·29
Lime	53·65
Phosphate of magnesia	·17
Phosphoric acid	·59
Organic matter	4·90
Undetermined, including traces of sulphur, potash and soda	·15
	100·00

The above results calculated out to the proximate constituents give the following:—

Calcium carbonate	91·02
,, phosphate	1·29
Magnesium phosphate ($Mg_3(Po_4)_2$)	·17
Aluminum phosphate with traces of iron ($Al_2(Po_4)_2$)	·29
Lime	1·98
Organic matter	4·90
Traces of sulphur, soda, and potash, undetermined	·15
Moisture driven off at 100° C	·20
	100·00

The amount of organic matter was determined by the loss on ignition after deducting the carbonic acid and moisture present; thus:

Loss on ignition (carbonic acid, moisture and organic matter) =	45·15%
Less carbonic acid 40·05% and moisture ·20% =	40·25
∴ organic matter .... =	4·90

This organic matter probably in part consisted of albumen, since both sulphur and soda were present; the acetic acid solution also, from which the flocculent organic matter had been filtered, became turbid on boiling, thus affording an additional confirmatory reaction for albumen. I much regret that the small quantity of shell at my disposal did not permit me to prosecute this part of the inquiry further.

The phosphates of alumina and of magnesia were determined by dissolving out the phosphate of magnesia by means of acetic acid from the precipitate containing the mixed phosphates thrown down by ammonia; the amount of iron present was so small that it was disregarded.

It will be noticed that 1·98 per cent. of lime in the above results is uncombined with any acid; it therefore probably existed as an organic compound, perhaps as an albuminate. The amount of carbonic acid found in the shell itself was 40·05 per cent., but on treating the ignited residue (of quick lime) with ammonium carbonate, and again determining the carbonic acid, 41·48 °/₀ was found, or an excess of 1·43 °/₀ over and above that furnished by the original shell itself; this 1·43 % of carbonic acid would by calculation require 1·82 per cent. of lime, whilst the actual excess of lime found was 1·98; the difference ·18 % between the calculated amount and that found is quite within the range of experimental error.

It was thought that perhaps it was just possible, although not very probable, that the shell had been subjected to the action of fire, and that part of the lime might still be in the caustic state; but nothing was found to confirm this momentary idea; the powdered shell turned red litmus paper blue, but not to a greater extent than does powdered marble; and, moreover, the presence of the organic matter found in all the fragments examined completely negatived the supposition that they had lost part of their carbonic acid by the action of fire.

The specific gravity of the shell was found to be 2·706 when taken in the form of powder; the uncrushed shell after long soaking in water gave a specific gravity of 2·530; and after warming until air bubbles ceased to be expelled, it was found to be 2·610; the difference between the first and second determinations gives a rough estimate of the amount of air space in the substance of the shell.

On comparing the results of the analysis of the Moa egg-shell with the analyses of recent egg-shells, it will at once be apparent that the composition of the Moa egg-shell differs but little from them; hence, it has in all probability undergone but a slight amount of change.

The following analysis of the egg-shell of the domestic fowl, made by Vauquelin, is quoted in Watt's Dictionary of Chemistry, vol. ii. p. 363:—

Calcium carbonate	89·6
„ phosphate with a little magnesium phosphate ..	5·7
Animal matter containing sulphur	4·7
	100·0

In the supplement to Watt's Dictionary, p. 549, the following analyses by W. Wicke are also cited:—

	Heron.	Gull.	Pheasant.	Goose.	Hen.	Duck.
Calcium carbonate....	94·60	91·96	93·33	95·26	93·70	94·42
Magnesium..........	·69	·76	·66	·72	1·39	·50
Phosphates	·42	·83	1·37	·47	·76	·84
Organic substances ..	4·30	6·45	4·64	3·55	4·15	4·24

V.—Classification of the Pliocene and Pleistocene Beds.

By Clement Reid, F.G.S.; of H.M. Geological Survey.

(Published by permission of the Director-General of the Geological Survey.)

In former papers on the Pliocene and Pleistocene Beds near Cromer, an account has been given of the character and succession of these deposits.[1] I have since obtained fuller information with regard to the beds beneath the Boulder-clay, and now give a more complete table, and also venture to propose the subjoined classification of the newer Tertiaries, reserving all details for the Survey Memoir.

On the Chalk near Cromer there is the shelly crag, which I have called Weybourn Crag. This is most intimately allied to the older crags, only one out of the fifty-four marine mollusca it contains being a fresh arrival.

[1] Geol. Mag. Dec. II. Vol. IV. p. 300, and Vol. VII. p. 55.

Above this is found the "Forest Bed Series," consisting of two fresh-water beds, with an intervening estuarine deposit (the "Forest Bed" of Norfolk geologists), containing large bones and abundance of drift wood and tree stumps. These divisions appear to be intimately connected.

Next comes the "*Leda myalis*" Bed, previously described. This having yielded a very small fauna, may ultimately be found to belong to the Pleistocene; at present it is left with the Crags.

At this point I should draw the line between Pliocene and Pleistocene, for the next deposit, the Arctic Fresh-water Bed, shows a marked change of conditions. Trees have entirely disappeared, and the plants include the dwarf arctic birch and arctic willow. The fauna and flora show the first incoming of arctic *land* species, and indicate a lowering of the temperature by about twenty degrees, a difference as great as that between the South of England and the North Cape at the present day.

The classification I have been led to adopt is founded upon the great oscillations of temperature, and corresponding changes in the animals and plants. Changes in the physical geography have also been taken into account, as they must always cause changes in the fauna and flora; but this branch of the subject I hope to deal with in the Geological Survey memoir.

It appears to be commonly felt that Lyell's classification, in which the Pliocene extends into the middle of the Glacial deposits, is very inconvenient; and in talking with geologists I find that they insensibly speak of Pleistocene as equivalent to the whole of the Glacial and Palæolithic periods. Professor Boyd Dawkins, on the other hand, wishes to separate the Forest Bed from the Crag, and class it with the Pleistocene, but it certainly is much more naturally connected with the older deposits.

For these reasons I think the classification here suggested will be the simplest, though it necessitates a slight alteration in Lyell's test, founded on the per-centage of extinct mollusca.

Glacial deposits of the North of England? and valley deposits of the south, newer than the Chalky Boulder-clay (Palæolithic period).	Newer Pleistocene. Decline of the cold.
Chalky Boulder-clay. Stratified beds (including Middle Glacial of Yarmouth.) Till. Arctic Fresh-water Bed. (First appearance of Arctic land species.)	Older Pleistocene. Commencement and great increase of cold.
Leda myalis Bed. Upper Fresh-water Bed. Forest Bed (estuarine). Lower Fresh-water Bed. Weybourn Crag. Chillesford Crag. Fluvio-marine Crag. Red Crag.	Newer Pliocene. (Upper or Fluvio-marine Crag.) Climate cold-temperate and probably nearly uniform during the whole period. Sea open to the north only.
Coralline Crag Black Crag of Antwerp.	Older Pliocene. (L. Crag.) Climate Mediterranean.

Most of the details of the above classification will, of course, be only applicable to the East Anglian District.

VI.—The Mammoth in Siberia.[1]

By Henry H. Howorth, F.S.A.

We have surveyed the distribution of Mammoths' remains in Siberia, especially of those in which the soft parts have been preserved, and have found them distributed along its whole length from the Kara Sea to the peninsula of the Chukchi. We have seen that these remains are found in large numbers, and that the further north we travel, the more abundant do they become. That while in Central Siberia they are comparatively unfrequent, as we near the Arctic border-land, the river banks and tundras teem more and more with them, until in the Bear Islands and the islands of New Siberia the ground is largely composed of the bones of Mammoths and the associated animals. These very abnormal facts, which are now familiar enough, have naturally attracted a great amount of speculation, and the question has arisen on many sides, How came they here? As we have seen, the unsophisticated natives explain the presence among them of carcases of huge animals with their flesh intact, by the elementary theory that the animals are still alive and live underground, dying only when exposed to the sun light.

Bayer, the famous Russian Academician, who wrote in the pre-critical days of Geology, urged that these remains were the *debris* of a vast campaign; that they were the remains of elephants which Chinghiz Khan had taken with him in one of his conquering marches, and which had perished on the way, quite oblivious of Chinghiz Khan's actual movements, and of his unacquaintance with elephants. The notion may be paired off with the similar suggestions explaining the presence of huge bones in Italy and Britain as the remnants of the respective campaigns of Pyrrhus and of Claudius. Isbrand Ides and other early travellers were at least more plausible when they invoked the Noachian deluge to account for what to them was undoubtedly a most extraordinary fact. These immature theories we only mention as historical curiosities, and pass on to more generally adopted ones. These may be limited to two hypotheses. First, that these animals lived much further south, and were carried down by the rivers to the sites where they are now found. Secondly, that they lived and died where their remains are now found. The former theory was once a favourite one. It seemed incredible that animals, whose nearest relatives now live only in tropical countries, should have existed under such very different conditions as must have prevailed in Siberia, and it was natural that speculation should have gone in the direction that these animals lived much further south than where their remains are now found, and should have been floated down the rivers of Siberia to the borders of the Polar Sea. When, however, carcases of the animals were discovered covered with woolly hair, evidently adapting them for a much colder climate than those of Africa or India, where their relatives have more or less bare skins; when, again, Brandt and others showed from an examination of the cavities in the teeth of the *Rhinoceros tichorhinus*, as I shall point out presently, that these pachyderms did not feed on tropical

[1] See former Articles in Geol. Mag. 1880, pp. 408 and 491.

plants, but on plants still growing in Siberia; when, again, it was considered how impossible it would be for carcases of huge animals to float down such rocky rivers as the Yenissei for hundreds of miles, and yet retain not only their flesh but their long hair intact,—opinion rapidly changed, and settled down to the view that these animals must have lived where their remains are found, and this is largely supported by other considerations. The remains are not only found on the banks of the long rivers and in the deltas which they form, but perhaps even more abundantly on the very short rivers which fall into the Arctic Sea, such as those between the Kolyma and the Indigerka. They are found also not only on the deltas of these rivers, but far away to the north, in the islands of New Siberia, beyond the reach of the currents of the small rivers, whose mouths are opposite those islands. They are found not only in North Central Siberia, where the main arteries of the country flow, but in great numbers east of the river Lena, in the vast peninsula of the Chukchi, in the country of the Yukagirs, and in Kamskatka, where there are no rivers down which they could have floated from more temperate regions. Again, the remains are not merely found in the beds or on the banks of rivers, but in nearly all parts of the tundra. Thus Wrangell says—"The best Mammoth bones as well as the greatest number are found at a certain depth below the surface, usually in clay hills, more rarely in black earth. The more solid the clay, the better the bones are preserved. Experience has also shown that more are found in elevations situated near higher hills than along the low coast or on the flat tundra" (Wrangell's Voyage, 286, note). Again, in another place he tells us these bones are found in clay hills, in the tundras, and along the banks of rivers; and he mentions how M. Bereslinor set off from Nijni Kolymak to find Mammoth bones on the eastern tundra (ib. 168). Again, they are found on the banks of rivers running south, like the Volga and the Ural, as well as on those of rivers flowing north. Again, if the home and habitat of the Mammoths had been further south, we should assuredly have found their remains chiefly prevailing there, while the contrary is the case; and the further we go north, the more abundant they become. Where, also, in Asia could a tropical habitat be found whence these animals could have floated? The great rivers of Siberia, the Lena, the Yenissei, and the Obi, sprung in a district where the winter climate is singularly severe; south of these head streams are the sand wastes of the Kirghiz Kazahs and of Mongolia, which were apparently a sea bottom in former times, and whose climate and other surroundings are even more adverse than those of Central Siberia. These physical difficulties point only to one conclusion. The same conclusion was arrived at by Brandt, from a consideration of the fact that the bodies and skeletons of Mammoths are sometimes found standing upright, as if they had sunk in that position into the soft ground. This was the case with the specimen found by Ssarytschef, near Alansk, already mentioned; with a skeleton found about 1827 near Petersburgh, as reported to Brandt by Pander; a third which was found in the peninsula of the

Obi, fifty versts from the mouth of the Yerambei; and a fourth found in the government of Moscow, all of which are discussed by Brandt (Bull. de la Soc. Imp. des Naturalists de Moscou, xl., part 2, 246–249). Lastly, it would seem that we can actually discriminate the Mammoths which are found in the furthest north from those found further south by certain idiosyncracies. Hedenstrom says that the bones and tusks are less large and heavy the further we advance towards the north, so that it is a rare occurrence on the islands, *i.e.* New Siberia, to meet with a tusk of more than three pood in weight, whereas on the continent they are said often to weigh as much as twelve pood (Wrangell, cxxxii).

In every way the problem is examined it becomes impossible to suppose that these remains have floated far, and the notion that they did so may be said perhaps to be almost extinct, and is certainly discarded by nearly all observers who know the country and are authorities on the Mammoth, by Brandt and Baer and Schrenck, etc., etc., Middendorf being the only exception known to me. We are remitted, therefore, to the alternative theory, that the Mammoths lived where their remains are now found. This theory, however, raises some considerations and postulates which have hardly been sufficiently considered. Considerations of climate and of food. The fact that the Mammoth was covered with short thick wool, and had besides considerable masses of long hair, which apparently formed a mane, and, perhaps covered the front part of the body, like those of the musk sheep and the bison, prove that the animal did not live under the same conditions as it does in Africa and India. It proves that its physique was adapted to a much more temperate climate. The same covering on the *Rhinoceros tichorhinus* argues the same conclusion. Brandt has examined the question of this hairy and woolly covering in great detail in a Memoir published in the Bulletin of the St. Petersburgh Academy. The same result has been arrived at from an examination of the remains of the food of the *Rhinoceros tichorhinus* found in the cavities of its teeth, to which we will revert presently, and which shows that the food of these Siberian pachyderms was very different to that of their relatives who now live in the tropics. The same conclusion may be deduced from an examination of the remains of the plants and fresh-water mollusks found imbedded in the same stratum with the Mammoths' remains. The same conclusion again is reached when we consider the present zoological distribution of some of the animals whose remains are found with those of the Mammoth, namely, the bison, the musk sheep, and the reindeer, all of which are animals confined to cold latitudes. These factors in the problem are unmistakable, and have been very generally held to prove that the climatic conditions under which the Mammoth lived were not at all tropical but rather the reverse. This is universally held, but at this point many of our inquirers have stopped short. Content to have proved this, they have concluded that the problem was in a measure solved, but this is far from being so. Granted that the Mammoth was fitted to live in a very temperate climate, fed on plants growing only in a temperate zone and associated with animals having their present abodes near the arctic circle, the further question remains, was it possible that these animals could live under the present climatic conditions of Siberia, and especially Northern Siberia?

I think I may say without hesitation that no inquirer, no student of this question, who has either himself been in Siberia, or who knows what the conditions of a Northern Siberian climate are, has ever answered this question affirmatively. Pallas, Middendorf, Baer, Brandt, Schmidt, Schrenck, etc., all are agreed on this, that the vast herds of Mammoths and the associated animals could not live in Northern Siberia under its present conditions. It needs but a very cursory examination of a physical map of Asia to show this. If we draw an isotherm marking the present southern limit in Siberia where the ground is permanently frozen all the year round, at two or three feet below the surface, we shall find it to include not only all the district in which Mammoths' bodies have been found more or less intact, but all the chief deposits of their bones, and if we inquire what kind of climate there is within this zone, we shall not hesitate very long in our answer. Travellers are agreed that the ground is perpetually frozen from two to three feet below the surface in all the country, and we are told the Yakuts merely dig holes in the frozen ground as meat safes (Tilesius, *op. cit.* 429).

At Dudimo, on the Lower Yenissei, Schmidt says vegetation does not begin to appear till the 16th of June, when the catkins of the willow and some green leaves began to thrust upwards through the snow, on the Yenissei islands and the Tundra he noticed no green till July, when the *Salix lanata* appeared, followed by *Nardosima frigida* and *Chrysosplenium alternifolium.* On the Tundra in the neighbourhood of the Jyda, the summer lasted from the 13th of July to the 5th of August. Even during this interval, he says in another place, there were constant north winds and frost at nights, while the land was covered with snow on the 28th of June through which the young shoots were appearing.

At the other end of Siberia, we find Billings describing the Chukchi land as consisting of bare valleys and naked hills with no vegetation, except a scanty grey moss that springs from among the stones, and serves as food for the Reindeer. Only in a few valleys did he observe a few stunted sand willows. The climate, he says, is the most melancholy that can be conceived; before the 20th of June there is no symptom of summer, and on the 20th of August the winter sets in again" (Wrangell, cxiii).

Speaking of the district of the Lower Kolyma, Wrangell says: "The vegetation of summer is scarcely more than a struggle for existence. In the latter end of May the stunted willow bushes put out little wrinkled leaves, and those banks which slope towards the south become clothed with a serene verdant hue. In June, the temperature at noon attains 72°; the flowers show themselves, and the berry-bearing plants blossom, when sometimes an icy blast from the sea turns the verdure yellow, and destroys the bloom. . . . Winter so called prevails during nine months of the year. In October the cold is somewhat mitigated by thick fogs and by the vapour rising from the freezing sea; but in November the great cold begins, and in January increases to —65°. Then breathing becomes difficult; the wild Reindeer, that citizen of the Polar region, withdraws to the deepest thicket of the forest, and stands there motionless as if deprived of life. . . . As the sun returns, the cold becomes even more sensible, and the intensity of the frost which accompanies the rising of the sun in February and March is especially penetrating" (*id.* 48 and 49).

The larger portion of North Siberia is now a naked tundra, on which no tree will grow; swept by terrible icy winds, and covered with moss, sprinkled with a few humble flowers, on such feeding ground it is physically impossible, as has been well said, that Elephants and Rhinoceroses could exist. They cannot graze close to the ground like oxen. They live on the foliage and small branches of trees, and on juicy canes and long grass (which grows shoulder high in the jungles and the beds of African rivers), and would starve even on one of our Craven pastures where the grass is close. This even in summer, but how in winter, which practically lasts for ten months in the year, when the tundra is covered deep with snow, and the terrible north wind sweeps across and makes it impossible for any but a very few singularly constituted animal to survive it? If we turn from the tundras to the rivers which thread them, we shall find that the limit of trees certainly goes further north in the river valleys than on the tundra, but only a comparatively short distance, and near the mouths of the Lena, the Obi, and the Yenissei, where such multitudes of Mammoths' remains have been found, there are no trees and no shrubs, but a bare waste; for the greater part of the year covered with snow, and for three or four weeks furnishing a slight covering of green, while the rivers themselves are for many months frozen hard to the depth of several feet, and everything everywhere is covered with thick snow.

Suppose that the Mammoths could outlive this terrible climate, a more important question remains how they were to find food. There is absolutely nothing here for them to eat in the winter, while in the summer the only herbage is such as they could not pasture. In this dilemma there seem to be only two alternatives, either to postulate a huge migration north and south as the seasons changed, or to postulate a change of climate. I do not wish to encumber this paper with any questions that may arise elsewhere than in Siberia, but to limit myself strictly to that district. There, a migration such as is referred to is perfectly inadmissible. In the first place, as we have tried to show, even in summer a large part of the district where the Mammoths are found is quite unsuited to their mode of feeding, and neither in quantity nor in quality of food could they supply their wants, they must inevitably starve. So that to come there in summer would be to migrate to a practical desert. For we must remember it is not a question of finding food for a sporadic pachyderm or two, but for enormous herds, whose hecatombs we have described. Again, if we consider the configuration of Siberia, and the vast distances over which this migration would have to pass, we shall come to but one conclusion. Where could the Mammoths from Kamskatka, or the banks of the Kolyma, or the islands of New Siberia, migrate to? Where, in fact, could any of those living on the shores of the Polar Sea migrate to, to gain a favourable wintering station? Lake Baikal and its neighbourhood have a terribly severe winter. South of these are the Mongolian Deserts. Even if the distances were possible, the want of a haven of refuge would prevent such a movement.

There remains, therefore, but one conclusion, namely, that the climate of Siberia has changed, has become much more severe and inhospitable, and this conclusion seems to be the one which is making its way among observers. The change of climate argued for is one from a temperate to an Arctic character. There is only one fact which seems to militate somewhat against this view, and which has had the effect of retarding reasonable conclusions on this subject. If you postulate such a change, it is said, what is to become of the Arctic fauna, the Reindeer, the Musk Sheep, etc., etc., associated with the Mammoth? This is a very fair question, and may, I think, be satisfactorily answered.

Those who have found small difficulty in postulating that an Elephant, a Hyæna, or a Hippopotamus, animals essentially tropical in their present distribution, should have lived in any part of Central or Northern Asia; who have had no difficulty in understanding how the Tiger should still live in Siberia and the Camel survive the icy temperature of Tibet, have apparently overlooked the fact that the Musk Ox and the Reindeer may have equally elastic constitutions. It is forgotten that the Reindeer undoubtedly thrived in Scotland, if not, as is very probable, in the days of the Norsemen, as one of the Sagas asserts, at all events when the Pictish forts were built, as my good friend Mr. Dawkins has shown, when the climate was apparently not much colder than at present, when the Shetlands and Orkneys were occupied by thriving woods, although wood will grow there no longer;—it is forgotten that, until comparatively recently, the Reindeer apparently abounded in the Southern Urals and in Livonia, and that it is still found largely in Manchuria, *where it is actually the prey of the Manchurian Tiger*. Similarly the skulls of the Musk Sheep have occurred in a very fresh condition much to the south of the present habitat of that animal, and there can be no doubt that both are well adapted to live in a comparatively temperate climate. The chief condition which seems to affect the distribution of animal life is apparently not climate; that is only a secondary element, but abundance or lack of suitable food, and in the case of the Reindeer and Musk Sheep, perhaps the antipathy of these animals and their kindred to damp. On this question I should like to quote some facts I published same years ago in illustration of another subject, and which I think apposite.

"Why will not the Reindeer now live in Scotland? The attempt to introduce it has been made more than once. The experiment has been described in considerable detail in Mr. Arthur de

Capell-Brooke's Travels in Lapland, 76, *et seq.* *Inter alia* he says: 'The reindeer, most contrary to expectation, was not only found abundantly in Scotland, but in most parts of England, particularly on Bagshot Heath, while the climate and even latitude of Scotland did not materially differ from the part of Norway whence they came. Notwithstanding these favourable circumstances, they died one by one, till I believe none remained in Scotland.' It cannot be the moss is not of the same quality, for, as Mr. Brooke says, the reindeer is by no means particular; it eats the leaves of the birch, willow and aspen, particularly the former, and browses also upon the young herbage and the tender shoots of the mountain shrubs. He gives a long list of the plants upon which it habitually feeds in summer (*op. cit.* 88 and 89). He also tells us that it is sometimes fed on hay in the winter. In this he is supported by Mr. Laing, who says that it eats grass and hay as well as moss. It lives on moss because there is nothing else to live on in the Fjeld (Residence in Norway, 264). There is therefore no reason in regard to its food why the Reindeer should not now live in Scotland. On turning to Iceland we have a different tale to tell. Twenty-four does were embarked from Hammerfest in Finmark for that island. They succeeded very well, and were soon so abundant that Sir George Mackenzie, in his work on Iceland, says they are not unfrequently seen there on the mountains in herds of sixty or one hundred together. It is clear therefore that some change has occurred recently in Scotland adverse to the mode of life of the reindeer. The obvious cause of this at first sight would be said to be that the reindeer thrives best in the coldest and most exposed situations: that Scotland and Southern Norway are too warm for it; while Spitzbergen, Greenland and Siberia are its more natural habitats, and this proves in some measure to be confirmed by the fact that the reindeer formerly in not remote times lived in Scotland at a time we have many reasons for believing the climate there was much more severe than it is now. This view would be partially, but not wholly correct. Mr. Capell-Brooke tells us at the same time that when the imported reindeer were dying in Scotland, others kept in confinement, and experiencing the very opposite reverse to their former mode of life, not merely survived but remained healthy and vigorous; withstood the effects of a London season, and an atmosphere most unusual to them, that of a room frequently crowded to suffocation (*op. cit.* 79)."

As I have said, reindeer thrive in the mountains north and east of Manchuria, a comparatively temperate region, and lived until quite recently, if not now, in the Southern Urals. On turning to Mr. Laing's most admirable narrative of a residence in Norway, I find the following passage, which I believe solves the difficulty. Speaking of the hair and skin of the reindeer, he says, "The former does not throw off wet well, and even parts from the skin after any continuance of moisture. With our damp climate and wet ground the animal would be drenched through the hair to the skin for weeks together, and would die of cold or rot, as our sheep often do in wet seasons. In Norway the heavy rains occur in spring or autumn, at which seasons what is rain below is dry snow up in the Fjeldes. Our highest hills do not afford in summer this kind of refuge from rain and damp to an animal whose coat keeps off any degree of cold, but will not stand continued moisture" (Laing's Residence in Norway, 264). It is the damp of our latitude now-a-days that the reindeer cannot endure. It is strange that no use has been made of this fact hitherto in zoological reasoning, for it is a very potent reason why so many foreign animals die here in our menageries. The beasts do not suffer from cold and other assigned causes as from damp. Diseases of the lungs are the scourges of such establishments, and these induced not by cold but damp. The camel, the tiger, etc., can endure the exceedingly bitter cold of the Tibetan plateau with impunity, because the cold is a dry parching cold. The lion which lived in historical times in the rugged mountains of Thrace need not fear the cold of our winters, but may well dread our damp seasons, which make such havoc even among our acclimatized people. That our climate has grown damper is probable from the contemporaneous extinction of the spruce fir with the reindeer, the former of which, as well as the other linear-leaved trees, according to Ermann, especially likes a dry air. I have no doubt, therefore, that the reindeer is quite capable of thriving and thriving well in temperate climates when other suitable conditions are at hand, and that it is a mistake to postulate an arctic climate wherever we meet with its remains.

Let us revert once more to the Mammoth. I am not aware that the contents of the stomach of any Siberian Mammoth have been hitherto examined, and we are reduced as to actual evidence of food to the results obtained from an examination of the fissures of the teeth of the Rhinoceros. This has been made by several observers. Brandt found bits of coniferous wood and remains of a seed. C. A. Meyer found the seed of an *Ephedra*. Mercklin distinguished the wood of a willow. The most elaborate examination of such frail debris was made in 1876, by M. Von J. Schmalhausen (Bull. St. Pet. Acad. vol. xxii. p. 291); he found in some brown matter scraped from a Rhinoceros teeth from Irkutsk remains of monocotyledons and dicotyledons, and recognized traces of a graminaceous plant, and of an ericaceous one, the latter probably *Vaccinium Vitis Idæa*. Among the remains of coniferæ were those of a *Picea* (? *obovata*), of an *Abies* (? *sibirica*) of a *Larix* (? *sibirica*), of a *Betula*, of a *Salix*, and of an *Ephedra*, all plants still thriving in Southern Siberia. The *à priori* evidence therefore is overwhelming, that when the Mammoths and their associated animals lived in Siberia, the climate was much more temperate. Let us now adduce such experimental evidence as we possess. We cannot of course take our thermometer with us to those days, but we can do something very like it, we can examine the debris of vegetation that has survived from those times. Plants at all events cannot migrate; they must stay the winter through, and they afford us therefore a good thermometer to mark where ancient isothermal lines passed. Fortunately remains of such plants have survived. These consist of two series, those which are the result of drift, and those which clearly grew on the spot. The shrewd observers who live in Siberia long ago discriminated between these kinds, and gave the name of Noashina to those which have drifted, and of Adamshina to the indigenous timber (see Tilesius, *op. cit.* p. 446), and this division is supported by Goppert, who separates the trunks of timber found in Northern Siberia into a northern series with narrow rings of annual growth and a southern with wider ones. The latter, as Schmidt says, doubtless floated down the rivers, as great quantities do still, while the former probably grew here with the Mammoth (Schmidt's Report, Bull. St. Pet. Acad. vol. xiii. p. 118).

Describing the fresh-water deposit in which the Mammoths' remains occur on the Lower Yenissei, Schmidt says: "It consists generally of clay alternating with layers of vegetable matter, consisting, like the similar layers of vegetable matter on the banks of the Tundra lakes, of water-mosses, grass, roots, leaves, pieces of branches, and layers of low weeds, which are covered in the spring floods with fresh layers of clay. . . . Where the lakes on the Tundra have grown small and shallow, we find on and near their banks a layer of turf, under which in many places *are remains of trees in good condition, which support the other proofs that the northern limit of trees has retrogressed, and that the climate here has grown colder.* I found on the way from Dudimo to the Ural Mountains, in a place where larches now only grow in sheltered river valleys, in turf on the top of the Tundra, *prostrate larch trees still bearing cones.* We also found on the Tundra under the turf near Sselakim, stems over half a foot in diameter; similar ones are only now found occasionally on slopes with a southern aspect. Lopatin found similar trees still more to the north in the cliff of Nikandrowskie Jary in 70½° N.L., while 11 versts above Krestowkoje, in 72° N.L., he found in a layer of soil covered with clay on the upper edge of the banks of the Yenissei, well-preserved stems like those of the birch, with their bark intact, and sometimes with their roots attached, and three to four inches in diameter. Professor Merklin recognizes them as those of the *Alnaster fruticosus*, which still grows as a bush on the islands of the Yenissei, in lat. 70½° N. While on the Tundra, near Swerevo, in 71° N.L., its present northern limit, it creeps along the ground with a stem but the thickness of one's finger. With the branches and roots of the *Alnaster*, Lopatin found a mass of fine twigs or branches, which shows it was not drift timber" (*id.* 112).

In the deposit where the Mammoth on the Gyda lay, Schmidt found some *Hypnum* mixed with the leaves of *Salix retusa*, var. *rotundifolia* and *Salix glauca*, which still live in the neighbourhood, and small bits of wood an inch thick and three to four inches long, and roots which Professor Merklin recognized as larchwood. No remains of larch were found in the layers above. "That the larch grew here" (where there is now only a bare Tundra) "is most probable. We have no reason to believe the Gyda ever sprang further north than it does now, while drift wood and rolled pebbles do not occur here" (*id.* 112–188).

Schmidt, in another letter, reports that he was told by a native of Heligoland, named Bolting, who had lived for twenty years at Yenisseisk, that at Dudimo, just at the limit of the woods, he had seen in a miserable larch wood, the lower part of a stem sticking in the ground apparently rooted, which was three feet in diameter (Mems. St. Peters. Acad. ser. vi. vol. v. p. 295–296).

Turning from Western to Eastern Siberia, we find Hedenstrom, who crossed the Tundra from the Indigerka to Ulsiank in 1810, saying, "On the Tundra, equally remote from the present line of forest, among the steep sandy banks of the lakes and rivers, are found large birch trees, complete, with bark, branches, and roots. At the first glance they appear to have been well preserved by the earth, but on digging them up they are found to be in a thorough state of decay. On being lighted they glow, but never emit a flame; nevertheless, the inhabitants of the neighbourhood use them as fuel, and designate these subterranean trees as Adamovshtshina, or of Adam's time. The first living birch tree is not found nearer than three degrees to the north, and then only in the form of a shrub" (Wrangell, cxxiv).

On the same journey he says he observed on Lake Chostag, which is fourteen versts long and six broad, that every autumn it throws up a quantity of bituminous fragments of wood, with which its shores in many places are covered to the depth of more than two feet. Among these are pieces of a hard transparent resinous substance, burning like amber, though without its agreeable perfume. It is probably the hardened resin of the larch tree. The Chostag Lake is situated 115 versts from the sea, and 80 versts from the nearest forest (*id.*).

In another place he mentions how, in a cliff from 30 to 35 feet high, beyond the Malaya Kuropalasik Vaga, and consisting of ice-clay and black earth, he drew out some interspersed roots, and found them to be birch, and as fresh as if only just severed from the trees. The nearest woods were 100 versts distant.

Samukof, we are told, found on the island of Kililnoi the skulls and bones of Horses, Buffaloes, Oxen, and Sheep in such abundance that these animals must formerly have lived there in large herds. At present, however, the icy wilderness produces nothing that could afford nourishment, nor would they be able to endure the climate. Samukof concludes that a milder climate must formerly have prevailed here, and that these animals may therefore have been contemporary with the Mammoth, whose remains are found in every part of the island. Another circumstance, whence he infers a change of climate, is the frequent occurrence, here, as well as in the island of New Siberia, of large trees partially fossilized (Wrangell, cxxix).

Erdmann says: "It cannot escape notice, that as we go nearer to the coast, the deposits of wood below the earth, and also the deposits of bones which accompany the wood, increase in extent and frequency. Here, beneath the soil of Yakutsk, the trunks of birch trees lie scattered, only singly, but on the other hand they form such great and well-stored strata under the Tundras, between the Yava and the Indigerka, that the Yukagirs there never think of using any other fuel than fossil wood. They obtain it on the shores of lakes, which are continually throwing up trunks of trees from the bottom. In the same proportion the search for ivory grows continually more certain and productive, from the banks of the lakes in the interior to the hills along the coast of the icy sea. Both these kindred phenomena attain the greatest extent and importance at the furthest chain of the islands above mentioned (*i.e.* New Siberia, etc.), which are separated from the coast of the mainland by a strait about 150 miles wide, of very moderate depth. Thus in New Siberia, on the declivities facing the south, lie hills 250 or 300 feet high, formed of drift wood; the ancient origin of which, as well as of the fossil wood in the Tundras, anterior to the history of the earth in its present state, strikes at once even the most uneducated hunters" (Erdmann, vol. ii. p. 379).

Herr von Ruprecht reported to Brandt that at the mouth of the Indiger, in 67° 39′ N.L., on a small peninsula called Chernoinos, where at present only very small birch bushes grow, he found rotten birch trunks still standing upright, of the thickness of a man's leg and the height of a man. In going up the river he met with no traces of woods until he reached the port of Indiga. Here he noticed the first light fir-wood growing among still standing but dead bushes. And higher up the river still, the woods fairly began.—Bull. of the Soc. of Nat. of Moscow, vol. xl. p. 254.

Trees are not the only debris of the life contemporary with the Mammoth which could not migrate, and which may be accepted as a kind of thermometer. In the fresh-water deposits in which the bones are found there are also fresh water and land shells which tell the same story.

Schmidt found *Helix Schrencki* in fresh-water deposits on the Tundra below Dudimo and beyond the present range of trees. Lopatin found recent shells of it with well-preserved colours, 9° further south, in lat. 68° and 69°, within the present range of trees at the mouth of the Awauka. The most northern limit hitherto known for this shell was in lat. 60° N., where they were found by Maak in gold washings on the Pit.

In the fresh-water clay of the Tundra by Tolstoi Noss, Schmidt found *Planorbis albus*, *Valvata cristata*, and *Limnæa auricularia*, in a sub-fossil state; *Cyclas calyculata* and *Valvata piscinalis* he found thrown up on the banks of the Yenissei, and on a rotten drifted trunk, *Amare agrestis*. *Anodonta anabora* he also found on the banks of the Yenissei as far as Tolstoi Noss, but no further. *Pisidium fontinale* still lives in the pools on the Tundra, as does *Succinea putris*, on the branches of the Alnaster on the Breschof Islands (Bull. St. Pet. Acad. vol. xiii. p. 130).

Again, he says, speaking of his journey from Tolstoi Noss to Dudimo, "On the top of the Tundra is often found Noah's wood and peat moss with *Planorbis*, *Limnæa*, and a large species of *Helix* which I have never found here alive" (*id.* 86).

The evidence then of the *debris* of vegetation and of the fresh-water and land shells found with the Mammoths' remains, amply confirm the *à priori* conclusion that the climate of Northern Siberia was at the epoch of the Mammoth much more temperate than now. It seems that the botanical facies of the district was not unlike that of Southern Siberia, that the larch, the willow, and the alnaster were probably the prevailing trees, that the limit of woods extended far to the north of its present range, and doubtless as far as the Arctic Sea; that not only the mean temperature was much higher, but it is probable that the winters were of a temperate and not of an arctic type, and roughly we may conjecture that Lithuania, where the bison still survives, and where so many of the other contemporaries of the Mammoth still live, probably presents to us a not unfaithful picture of what Northern Siberia must have been like from the Urals to Behrings Straits, and that it was probably in such a condition of things as prevails in Lithuania that the Siberian Mammoth thrived the best.

We have seen reason, therefore, to conclude that the Mammoth lived in all parts of Siberia where his remains are now found, and that when he lived there, a comparatively mild climate prevailed in Northern Asia to the very borders of the Arctic Sea. These are not the only nor the most important lessons which we can learn from the Mammoth remains of Siberia. Other conclusions of a more revolutionary and heterodox character seem to us to be inevitable corollaries from the facts. Before we venture to propound them, however, we must shortly examine the problem in other areas than Siberia, where Mammoth remains abound, *i.e.* in Europe and America, and to this we hope hereafter to devote another paper.

NOTICES OF MEMOIRS.

I.—Cenni Sulla Geologia Della Galita. Prof. A. Issel. Ann. del Mus. Civ. di St. Nat. di Genova, vol. xv., 1880, with coloured Map.

PROFESSOR ISSEL, who made one of the party in a cruise from Genoa to the north coast of Africa, in the cutter "Violante," belonging to and commanded by Capt. Henry Albertis, has already written an account of the voyage, and now adds a sketch of the geology of the Galita islands north of Tunis.

The largest island Galita is two miles and three-quarters long by one mile and a half broad. The higher parts of the islands are composed of granite, while a large portion of the island Galita is composed of travertine containing the remains of some indeterminable herbaceous plants and *Helix vermiculata*, Müll., *H. aspera*, Müll., *H. submeridionalis*, B., *H. amanda*, Ross, *H. trochoides*, Boiret, *H. Kabiliana*, *H. Berlieri*, species of shells which Prof. Issel also now found living on the islands. This formation belongs to the Quaternary period, and probably after the Glacial period, and he supposes that the elevation of the island took place at the time of the great elevation which raised the marine bed of the African desert.

In some parts of the coast, and especially along the southern shores, there is a marine Quaternary deposit showing a recent elevation of the island.

Bory de St.-Vincent, Renou, and Velain, are the only authors who have previously described the geology of these islands, and their opinions do not coincide. Bory de St.-Vincent spoke of the rocks of Galita as trachyte, and speaks of the islands being raised by volcanic agencies. Renou, on the other hand, described a grey granite as existing on the island Galita, with melaphyre or diorite at the extremities of the island, a large extension of black unfossiliferous calcareous rock which he considered of Jurassic age. Velain mentions eruptive rocks, and speaks of trachytes having much analogy with the andesites of the equator and the blue porphyries of L'Esterol.

Finding this difference of opinion concerning the crystalline rocks, Prof. Issel brought back a large series of specimens, and gave them a very careful macroscopical and microscopical examination, and also submitted some of them to Prof. Grattarola, who, after similar examination, confirmed Prof. Issel's opinion that it was a true granite, and said he had some specimens of Elban granite which could with difficulty be distinguished from it.

Prof. Issel considers that the difference of opinion arrived at by experienced geologists is because the granites of Galita sometimes assume the aspect of certain quartziferous trachytes, besides perhaps there is not an essential difference, and the characters by which granites are distinguished from the trachytes depends probably on the different age, and the particular condition under which consolidation has taken place.

This group of islands is really a prolongation of the granitic mountains of Sardinia. The schists which had been described as Jurassic are thought to be of Silurian age, corresponding to some not far off in the north of Africa. A. W. W.

II.—Journal of the Royal Microscopical Society. Vol. III. Nos. 1—5. February to October, 1880. With several Plates. 8vo. (Williams & Norgate, London and Edinburgh.)

THIS Journal contains also the Transactions and Proceedings of the Society, and a record of current researches relating to Invertebrata, Cryptogamia, Microscopy, etc., including Embryology and Histology generally, and is edited, under the direction of the Publication Committee, by Frank Crisp, LL.B., B.A., F.L.S., one of the Secretaries of the Society, assisted by Messrs. A. W. Bennett, Prof. F. Jeffrey Bell, and S. O. Ridley, Fellows of the Society.

A special feature of the Journal is the Classified Record, which it contains, of the work of British and Foreign observers relating to the Invertebrata, Cryptogamia, etc., as appearing in more than 300 of the principal Journals and Transactions of this and other countries; notes and abstracts being furnished of the memoirs and papers, and arranged systematically.

The bibliography, or list of titles, is also classified as follows:

ZOOLOGY.

A. GENERAL (including Embryology and Histology of the Vertebrata).

B. INVERTEBRATA. — Mollusca. Molluscoida. Arthropoda: (α) Insecta. (β) Myriapoda. (γ) Arachnida. (δ) Crustacea. Vermes. Echinodermata. Cœlenterata. Porifera. Protozoa.

BOTANY.

A. GENERAL (including Embryology and Histology of the Phanerogamia).

B. CRYPTOGAMIA. — Cryptogamia Vascularia. Muscineæ. Characeæ. Fungi. Lichenes. Algæ.

MICROSCOPY, etc.—Methods. Instrumental, etc.

The only exception to the completeness of the Bibliography (within the prescribed limits of the Invertebrata, Cryptogamia, etc.) is in regard to (1) the Insecta, only such articles being noted as are of general interest, lists and descriptions of new species, local faunæ, etc., being omitted; and (2) Palæontology, which is dealt with so far only as bearing on living forms or structural features; and, for the present, only a few of the principal Geological Journals, etc., are included.

Even within these limits many points of interest are brought within the notice of the English student and geologist, either of actual importance or suggestive of further inquiry. The biological notices are frequently of direct interest to the student of fossils, and of the life of a species.

In illustration of the geological contents of the biological record in this valuable bi-monthly Journal of the Royal Microscopical Society, we quote the following:—

"*Aspidura.*[1]—Dr. Hans Pohlig gives a fresh definition of this interesting Triassic Ophiurid, from the Muschelkalk of Germany, which he divides into two subgenera, *Amphiglypha* and *Hemiglypha*, of which the former is broader and has shorter arm-spines than the latter; in each case a single species is alone known. He regards this form, which is the only Ophiurid as yet found in this stratum, as representing an extinct genus, which is distinguished from all its allies by the possession of larger, closely connected, radial shields, and by the bilateral groove on its oral shields; belonging to the Ophiolepidæ, it is intermediate in character between *Ophioglypha* and *Ophiopus*. *Hemiglypha* has many points of resemblance to the Asterida, and appears to occupy a similar position among the Ophiurida to that held by *Brisinga* among the Asterida.

"It may be interesting to observe that Pohlig agrees with Haeckel in regarding the Asterida as the older forms."

[1] Zeitschr. wiss. Zool. vol. xxxi. (1878) p. 235.

III.—I Diaspri della Toscana e i loro Fossili. Per Prof. Dante Pantanelli. Mem. della Reale Accad. dei Lincei. Ser. 3, vol. viii. June, 1880.

PROF. DANTE PANTANELLI has presented a valuable memoir on the Jaspers of Tuscany, in which he has found, as mentioned in his preliminary announcement, a large number of *Radiolaria*.[1]

In the definition now given of the rock, it is said to be constituted of amorphous silica, together with crystallized silica, stained with metallic and earthy oxides, often distinctly crystallized in the mass of the silica. It contains the remains of organisms with siliceous skeletons, and occurs in clefts and in raised and stratified masses.

This "diaspro" is abundant in various horizons of the Upper Eocene of Tuscany, and is found in stratified layers which rarely exceed five centimètres between the hard masses of clay called galestro, and sometimes between incoherent material or strata of siliceo-calcareous rocks.

Professor Pantanelli describes thirty-two species of *Radiolaria* from the "diaspro," and says they are larger than their living allies, and after a criticism of the results of the *Challenger* and other expeditions, concludes that these deposits have been formed in not less than one thousand mètres, for the number of *Radiolaria* is known to increase with the depth, while the number of Foraminifera on the other hand diminishes.

Geologists have maintained that the origin of diaspro was metamorphic, or at least the result of silicification posterior to deposition, until De Stefani a few years ago doubted the correctness of this idea, and it is now shown that the rock in question cannot be formed by metamorphism caused by the vicinity of igneous rocks for several reasons; among others, it could not attain such great thickness, nor as now shown contain fossils; nor is it only found in the Eocene, where metamorphic action might be attributed to the serpentine, but also in the Chalk and Lias, where no eruptive rocks are known; and further, in the Eocene the "diaspro" is often very far from any igneous rocks. Calcareous or sandy strata are sometimes intercalated in the galestro, and in the same way the serpentines are sometimes separated from the galestro by unaltered calcareous strata.

Professor Pantanelli considers that this compact rock is formed in much the same way as calcareous ones by analogous phenomena, the incoherent material in this case being agglutinated by the silica in solution in the acid water, so that the cracks, instead of being filled with calcite, as in the latter case, are full of quartz.

Stoppani, De Stefani, Bonney, Issel, have recently maintained that the serpentines represented true submarine lavas of the Upper Eocene, and this receives additional support, or rather proof, from the present discovery, and at the same time the presence of these fossils excludes the idea of the galestro and other of the series having a metamorphic origin.

A. W. W.

[1] See preliminary notice, Geol. Mag. 1880, July No. p. 317.

IV.—I Terreni Sabbiosi e la Fillosera. Boll. del R. Comit. Geol. d'Italia. July, August, 1880.

The Italian Minister of Agriculture communicated to the engineer of the mines at Caltanisetta in Sicily the observations of the French Society of Agriculture, relating to the soils in which the Phylloxera was most abundant. It appears that they noticed that the vines in argillaceous and compact soils fell a victim to the Phylloxera, whilst in sandy soils they were unaffected. The most favourable being soils with a large proportion of siliceous, and not above 12 per cent. of calcareous sand. It was found that, where the roots of vines passed through two strata, one sandy and the other argillaceous, the part of the root which traversed the argillaceous soil was covered with Phylloxera, whilst the rest passing through the sand was healthy, and not at all attacked by the insects.

In reply to this, Sig. P. Posi sends a very interesting report on the geology and culture of the vine in Sicily. Most are grown on volcanic soils, but all volcanic rocks are not suited for vine culture, as when it is vitreous nothing will grow, whereas felspathic lavas, rich in potash and easily subject to atmospheric decomposition, are eminently fitted for growing vines; but the most productive of all are the extensive deposits of fine ashes. Sig. Posi says that the rain of ashes during the last eruption added so much to the fertility of the soil that it much more than compensated for any damage done by the eruption to the forests and other cultivated land. He points out that the physical nature of these ashes approaches so much to that of loose sand that it may very possibly resist the invasion of the phylloxera, and thinks it worthy of further experiment, seeing that while it contains the necessary elements for the growth of the vine, there is no argillaceous material to favour the growth of the phylloxera. After the volcanic earths, most of the vine culture is in the Pliocene and Miocene sands, with but little in the marly districts.

A. W. W.

REVIEWS.

I.—Annales de la Société Malacologique de Belgique. Tome XII. 2ième Ser. tome ii. (Brussels, 1877.)

The Annals of the Belgian Malacological Society for the year 1877, just issued, contains, in addition to geological and malacological papers and the bulletins of the Society, an exhaustive list of eight 8vo. pages of titles of memoirs relating to living and fossil Brachiopoda. This useful and very complete bibliography was compiled with considerable labour and research by Mr. Thomas Davidson, F.R.S., the chief historian of the group, who, it is evident therefrom, has himself contributed since 1847 over fifty memoirs to the literature of the class. The list contains more than 1,200 alphabetical entries, from the earliest publications of the seventeenth and eighteenth centuries of Colonna (in 1606), Pallas, Rumphius, and Cuvier, up to the more recent works of Owen, Hancock, Huxley, King, Morse, Kovalevsky, etc., until the month of April, 1876. It was intended as an appendix to the French translation of the author's memoir, "What is a Brachiopod?" published in the Annals of the same Society for 1875. The list includes the titles, locations, and date of issue of papers relating in any way to the anatomy, classification, embryological and palæontological history, geographical and geological distribution of the Brachiopoda, and therefore cannot fail to be of great use to future students of this extensive group of organisms. It will, we understand, be eventually reproduced in the volume of the Palæontographical Society for 1882, on the conclusion of Mr. Davidson's series of valuable supplementary memoirs on the British Fossil Brachiopoda. Any corrections of the present issue, or suggested additions thereto, will be welcomed by the author, for the purpose of rendering the bibliographical history of the group fully accurate and complete. A. C.

II.—Geological Survey of Victoria. Prodromus of the Palæontology of Victoria. Decade VI. By Fred. McCoy, (Melbourne, 1879; London, Trübner & Co.)

THIS Decade, like the previous ones, contains figures and descriptions of some of the more important Victorian Organic Remains. The illustrations are equally divided between vertebrate and invertebrate fossils. The description of the extinct gigantic Kangaroo, *Macropus Titan*, Owen, so common in the Pliocene deposits, is followed by that of the curious extinct Marsupial genus, *Procoptodon*, which differs from the true Kangaroos in the character of its teeth, and shows a relation to the extinct *Diprotodon* of the same Pliocene deposits. Three species of *Cetotolites* are noticed from the Miocene near Geelong, showing the extraordinary repetition in Australia of the curious occurrence in the Crag of Suffolk of similar ear-bones of whales. The teeth of a gigantic fossil species of Spermaceti Whale, *Physetodon Baileyi*, McCoy, from the older Pliocene, and a tooth of *Squalodon*, are figured on the fifth plate. Descriptions and figures are given of some fossil mollusca (*Orthoceras*), characteristic of the Upper Silurian, and of a new species of *Hinnites* from the Miocene. The last two plates represent some interesting species of sea-urchins belonging to the genera *Lovenia*, *Monostychia*, and *Clypeaster*, which are widely distributed in the Tertiary strata (Miocene and Pliocene) of the Colony. J. M.

III.—Practical Blowpipe Assaying. By George Attwood, F.G.S., Assoc. Inst. C.E., etc. (London: Sampson Low & Co., 1880.)

Blowpipe Analysis. By J. Landauer. Authorized English Edition by J. Taylor and W. E. Kay. (London: Macmillan & Co., 1879.)

AS an instrument of chemical and mineralogical research, the Blowpipe is probably not so highly estimated as it ought to be in this country, not that manuals descriptive of its applications and methods of use are wanting. The English pyrologist is fairly supplied with them, either as original treatises, or translations with or without modifications of the best Continental works, from the translation of Berzelius in 1822 to the present time. Of the recent contributions to Blowpipe literature, besides the smaller work of

Major Ross on Pyrology (1880), are the two mentioned at the head of this notice.

The "Blowpipe Analysis" of Landauer is treated entirely from a chemical point of view, in contradistinction to most works on the same subject, which give in great details the mineralogical rather than the chemical aspect. The first and second chapters are devoted to the various apparatus and re-agents used in Blowpipe analysis. The third chapter contains the special examination of certain elements in combination; and the fourth chapter comprises the systematic examination of compound substances, divided into preliminary and complete examination,—a division perhaps unnecessary—together with Egleston's method of examination of compound minerals, followed by a condensed view of Blowpipe re-actions, and a reproduction of Plattner's "Tabular View" of the behaviour of minerals before the blowpipe.

A plate of the spectra of the metals of the alkalies and alkaline earths, and an extended description of Bunsen's flame re-actions, accompany this useful Blowpipe manual.

Mr. Attwood's book is somewhat different, both as to arrangement and contents, from many of the ordinary treatises on the blowpipe, being intended as a guide to Blowpipe Assaying. A brief introduction, containing tables of the elements according to their commercial and non-commercial value, is followed by a description of the mouth blowpipe, re-agents, and necessary apparatus, among which we notice two portable forms of assay balances suggested by the author. The second part contains the qualitative determination of the principal alkalies, earths, and metals, the rarer substances being placed together at the end. The third part is devoted to the assay of the ten chief metals of commercial importance, Silver, Gold, Mercury, Copper, Lead, Bismuth, Tin, Iron, Nickel, and Cobalt, concluding with the assay of Coal. In the last part will be found a series of elaborate tables, with explanations of their use, of American and English values of Gold according to its fineness.

This work, while it may be usefully consulted by the ordinary blowpipe analyst, is more especially intended for the mining prospector and blowpipe assayer; the author's long experience in mining researches having taught him the value of the blowpipe in the field where no other method of assaying is so readily available. J. M.

IV.—Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie. Commenced by K. C. von Leonhard and H. G. Bronn; continued by G. Leonhard and H. B. Geinitz, etc. Nos. 1–9, for 1878, with Woodcuts and 15 Plates. Nos. 1 and 2, for 1879, with Woodcuts and 4 Plates. 8vo. (E. Koch, Stuttgart.)

Neues Jahrbuch, etc. Edited by E. W. Benecke, C. Klein, and H. Rosenbusch, with the co-operation of several professional colleagues. Nos. 4–9, for 1879, with 5 Plates and several Woodcuts. 8vo. (E. Koch, Stuttgart.)

We have here before us the highly useful German periodical, the progress and value of which we have so often noticed, full of excellent papers on Geology in its various branches, but more particularly as to Petrology, Mineralogy, and Crystallography, though Geology proper is not wanting, and Palæontology is not without good representative memoirs. Unfortunately, it seems that scientific periodicals do not pay well anywhere; and our German brethren are advised by their publishers to enliven their magazines, if possible, and at the same time try to bring them out with the least possible expense, so that the publishers shall not regret having to do with science. After many years of hard struggling against the impecuniosity of working savants, against the hard times of civil commotion, and against the competition of more or less scientific rival publications, the "Neues Jahrbuch" (which commenced as the "Jahrbuch," etc., in 1830, and re-started as "New" in 1833, living on with the lives of two eminent editors, and then surviving for some years under two others, and until 1879 under one of these) has been led to another phase by its publisher and a new company of editors. "In the midst of counsellors there is safety;" and three editors, with a committee of several others, equally energetic and well prepared, hope well of the future. The new staff of professional geologists and mineralogists can, doubtless, supply enough material for the "Jahrbuch"; but the publisher has economised his expenses over the periodical by less frequent issues during 1879, and proposes to send out only two parts or volumes for the "Neues Jahrbuch" of 1880, each consisting of three numbers of fifteen sheets each. The price will be 20 marks a volume. Whatever the form or the price, we trust that geologists at large will not be losers. Publishers have their own views of the value and the profits of books; and we sincerely trust that the "Neues Jahrbuch" will be profitable to its proprietor in its new form, for it has always been, and we trust will be in the future, of very great value to geologists. The volume for 1878, under our old friend Prof. Dr. H. B. Geinitz's care, besides a great collection of letters, notices, and abstracts, as heretofore, contains the following original papers:—

H. Höfer, on the Giant's Chaldrons near Pörtschach, in Carinthia; F. Sandberger, on Basalt and Diorite, near Schwarzenfels in Hesse; A. Baltzer, on the Geology of the Swiss Alps (contact-phenomena at the north boundary of the Finstaarhorn central mass, two papers); Th. Wolf, Cotopaxi, and its Eruption of 26th June, 1877; Friedrich Scharfe, Topaz and Quartz; K. Dalmer, the Felspar-Pseudomorphs of the Wilhelmsleite, near Ilmenau; A. Wichmann, on the Sericite Rocks of the Taunus; E. Kalkowsky, on the Granite-porphyry of Beucha, near Leipsic; A. Kenngott, on the Fundamental Conditions of the Crystal Species; A. Knop, on the Hydrographical Relations between the Danube and the Aix Springs on the Baden Highlands; J. J. Pohl, on a Simple and Sure Method to distinguish true Turquoise from its imitations; H. Trautschold, on Methods and Theories in Geology; H. Goeppert, on the Quantitative Proportion of Amber; Karl Zittel, on the Classification of Fossil Sponges; A. von Lasaulx, Mineralogical Work in the University of Breslau; B. Lundgren, on Angelin's Geological Sketch-map of Sweden; A. Streng, on the Silver-pyrites of Andreasberg, and on the Ores of Charñacillo in North Chile; H. Conwentz, on the Tertiary Occurrence of Cypress-like wood near Calistoga in California; F. Gröger, on the Phenomena of Earthquakes and Volcanic Eruptions; Ad. Schmidt, the Quartz-diorite of Yosemite, and a variety of Hornstone.

The first and second Nos. for 1879 (under the old management) contain:—

K. A. Zittel's third paper on Fossil Sponges; Richard von Drasche's two Geological Journeys through the Island of Niphon, Japan; H. B. Geinitz, on two new Cretaceous Plants; E. Dunker, the Temperature in Bore-hole No. 1 at Sperenberg; and A. Hilger's Notes on the Chemical Laboratory of the University of Erlangen, as original papers, besides the usual complement of letters and bibliographical lists of abstracts.

The third and fourth Nos. for 1879 (in one), with the new editors, contain—

Val. von Möller, on the Bathrological Place of the younger Palæozoic System of Djoulfa in Armenia; Hans H. Reusch on the Working of the Sea on the west coast of Norway (translated by R. Baldauf); W. C. Williamson and E. Weiss, on Sphenophyllum, Asterophyllites, and Calamites, their relation one to another; R. von Drasche, on Palæozoic Beds in Kamtschátka and Luzon; K. von Seebach, Foyaite and the Sierra de Monchique; F. Klocke, on the Optical Structure of Ice; Otto Luedecke, on Reinite, a new wolfram-iron mineral, from Japan; F. M. Stapff, the Mechanics of Faults; J. Hirschwald, the Microscopic Goniometer for measuring crystals with dull facets; A. von Koenen, the Culm Fauna of Herborn.

The fifth, sixth, and seven Nos. (in one) have:—

L. von Werveke, on Limburgite; A. von Lasaulz, the Sulphur Districts of Sicily; C. Klein, Mineralogical Notes; J. Hirschwald, measurings by the Microgoniometer; A. Streng, Fireblende and Rittingerite.

Nos. 8 and 9 (in one) contain of original papers the following:—

A. Lösch, on Lime-iron-garnet (Demantoid), from Lyssertsk in the Ural; F. M. Stapff, on Faults (continued); L. van Werveke, on the rocks of the Island Palma; F. Wöhler, on the native Iron of Greenland; S. M. Badcock, on the Celestine from the Muschelkalk of Jühnde, near Göttingen; and E. Cohen, on the Eclogite from the Diamond Mines of Jagersfontein, Orange Freestate, South Africa; Obituary of Bernard von Cotta, by A. St.

Letters addressed to the various editors on the subjects of their special departments, and as usual often rich with interesting and suggestive facts and notions, together with extracts and abstracts of papers on mineralogy, geology, and palæontology, with lists of new books and periodicals, complete the parts, as heretofore, but with rather different arrangement. T. R. J.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 3, 1880.—Robert Etheridge, Esq., F.R.S., President, in the Chair.

The President announced that the original portrait of Dr. William Smith, painted by M. Fourau in the year 1838, had been presented to the Society by William Smith, Esq., of Cheltenham.

The following communications were read:—

1. "On the Serpentine and Associated Rocks of Anglesey, with a Note on the so-called Serpentine of Porthdinlleyn (Caernarvonshire)." By Prof. T. G. Bonney, M.A., F.R.S., Sec. G.S.

Several patches of serpentine are indicated on the Geological Survey map on the western side of Anglesey, near Tre Valley station, and a considerable one on Holyhead island near Rhoscolyn. These really include three very distinct varieties of rocks: (1) compact green schistose rocks, (2) gabbro, (3) true serpentine. The author described the mode of occurrence of each of these, and their relations, the serpentine being almost certainly intrusive in the schist, and the gabbro in the serpentine. The microscopic structure of the various rocks was described in detail, especially of the last. It presents the usual characteristics, and is an altered olivine rock which has contained bronzite. One or two varieties are rather peculiar; an ophicalcite and a compact chloritic schist containing chromite are also noticed. At Porthdinlleyn there is no serpentine, but a remarkably interesting series of agglomerates and (probably) lava-flows of a basic nature, which may now be denominated diabases.

2. "Note on the Occurrence of Remains of Recent Plants in Brown Iron-ore." By J. Arthur Phillips, Esq., F.G.S.

The fossilizing ironstone described by the author occurs at Rio Tinto, in the province of Huelva, Spain, in close proximity to the celebrated copper-mines of that name, where it forms a thick horizontal capping of a hill known as the Mésa de los Pinos. In this iron-ore Mr. Carruthers has identified the following vegetable remains:—Leaves and acorns of *Quercus ilex*, Linn.; leaves and seeds of a two-leaved species of *Pinus*, most probably *Pinus pinea*, Linn.; the cone of *Equisetum arvense*, Linn.; and a small branch of a species of *Erica*. There is also a well-marked leaf of a Dicotyledonous plant not yet identified. A great portion of many of the specimens consists of a thick growth of moss; but it is impossible to say what the species are. The whole is permeated with minute branching roots, showing that the vegetation was formed as a great mass, the oak- and pine-leaves having been probably carried or blown into it. The plants are evidently all of the same species as are still growing in Spain.

The author attributes this deposit of ironstone to the decomposition, partly by organic agency, of ferruginous salts, derived from the oxidation of iron pyrites, which flowed into a marsh or shallow lagoon. Subsequently to this the valleys of the Rio Agrio and Rio Tinto were eroded, leaving the Mésa de los Pinos with its thick capping of iron-ore.

The very recent character of this deposit is evident from the fossils it contains; but the erosion of the valleys certainly took place before the Roman occupation of the district. This is satisfactorily shown not only by the position of various remains of that date, but also by the fact that the Roman grave-stones, which are still remaining in the locality, are made of this ironstone.

3. "Notes on the Locality of some Fossils found in the Carboniferous rocks at T'ang Shan, situated, in a N.N.E. direction, about 120 miles from Tientsin, in the province of Chih Li, China." By James W. Carrall, Esq., F.G.S. With a Note by Wm. Carruthers, Esq., F.R.S., F.G.S.

The author described the locality from which he obtained some plant remains of apparently Carboniferous age, and stated that mining-operations had been carried on by a Chinese company in the district since the year 1878. Several seams of coal occur, varying in thickness from 11 inches to 6 feet. Mr. Carruthers stated in a note that the specimens submitted to him belong to a species of *Annularia*, probably *A. longifolia*, Brough, abundant in the British Coal-measures, and found both on the Continent and in North America.

Geologists' Association.

THE first ordinary meeting of the session was held on Friday evening, 5th November, when the usual anniversary address was read. The President (Professor T. Rupert Jones, F.R.S.) took for his subject "The Origin and Progress of the Geologists' Association." A proposal for the formation of an Association of Amateur Geologists was started in the "Geologist" of August, 1858; and, although the writer of the first letter never came forward, yet the subject was taken up by others, notably by Mr. G. S. Penson, in the October number of the "Geologist," p. 449, and by Mr. J. E. Wakefield and the late Mr. E. Cresy (of the Metropolitan Board of Works), among their friends and others interested in the scheme of studying geology by mutual help and on an economical plan. Mr. George Potter, Mr. J. Toulmin Smith, Mr. J. Slade, Mr. J. E. Saunders, the Rev. T. Wiltshire, and Mr. F. J. Furnivall, were especially enthusiastic in the project, and among the early founders of the Society. After some preliminary meetings at Highgate, at 2, Upper Wellington Street, and at 45, Great Ormond Street, and the issue of a prospectus, the first ordinary meeting of the Association was held at St. Martin's Hall on Jan. 11, 1859. Mr. Toulmin Smith, the first President, resigning in February, was succeeded by the Rev. T. Wiltshire, who, with Mr. J. E. Wakefield as honorary secretary, and with 164 members in the first year, most successfully carried on the young society with the aims of its founders. The object in view was to facilitate the study of geology and its allied sciences among associated amateurs, by the reading of papers, the delivery of lectures, the formation of a library and a cabinet of typical fossils, the practice of field-lectures or excursions, and the publishing of proceedings. On each of these branches Professors Rupert Jones made some observations, as to the cultivation they had received, and the fruit they had borne. He noticed also some subsidiary points of interest in the constitution and administration of the Society. The periodical meetings for the reading and discussion of papers, for the interchange of thought and information by word-of-mouth, and for the exchange of specimens, were important in the existence and well-being of the Association; and, except as regards the exchange of specimens, they had been well attended to. The character of the papers, not always devoted to new matter, but often résumés and explanations of known facts and observations, was dealt upon; and good results had been and were to be obtained among amateur geologists and students by the reading and publication of such papers. The failure of the "exchange," and the disappearance of the collection of fossils, were treated of, and the former in a modified form was recommended for consideration. An earnest plea for more books was advanced. The Excursions and visits to Museums are well known to have been remarkably successful, and very useful, especially if reports have been published of their geological details. The class-lectures were soon discontinued; but it is doubtful if they would not be useful still. The intercommunication with Societies and Field-clubs in the Counties has often been recommended, and to a great degree effected; but the re-institution of Honorary Local Secretaries, and with them the formation of *local geological committees* in communication with the Association, was recommended. The high value always and rightly placed by the Associates on the presence of ladies at the meetings was duly mentioned; and, to insure their company in the field as well as in town, it was suggested that special excursions, free from mountainous and rough ground, should be periodically arranged. The high esteem in which the Association is held by home and foreign geologists was not forgotten; and the Members were congratulated on the success of their Society, and advised to keep to the lines and precepts of their founders.—*Mining Journal.*

CORRESPONDENCE.

MORTERATSCH GLACIER, ENGADINE.

Sir,—In the month of August, 1875, a friend and I agreed to get an approximate measurement of the rate of movement of this glacier. With this object we walked from the glacier snout, along the mountain side, on the left, till we saw a large boulder on the medial moraine, and also a rock *in situ*, on the mountain side on the right, at about the same level. We then found a spot on the left side, on looking from which we got the boulder and the rock *in situ*, in line. As these were of considerable size (the boulder being about 80 cubic feet), we pointed a strong line on each of them, and set up a post at the stand-point. This was about 3 furlongs above the snout of the glacier. Here the glacier is about half a mile wide, the boulder to the large medial moraine being 500 yards from the left side, or stand-point.

To estimate the movement, one person went on the moraine, near the boulder, while another was posted at the stand-point, and the latter signalled to the former to move to the right, or left, till he got to a spot which lined with the rock *in situ*. This was marked, and the distance to the boulder was measured.

In 1875, three observations were taken, two at intervals of 10 days and one at 24 days.

My frend has not been in the Engadine since. I have been here every year since. In 1877, 1879, and this year, I have measured the progress of the boulder, in the manner described.

The result is as follows:—

The average daily movement, in 2 years, Aug. 1875 to Aug. 1877, was 1·48 in.
in 2 years, Aug. 1877 to Aug. 1879, was 1·22 in.
in 1 yr. and 9 days, Aug. 1879 to Aug. 1880, was 1·28 in.
in 5 yrs. and 9 days, Aug. 1875 to Aug. 1880, was 1·34 in.
in 44 days, 7th Aug. 1875 to 20th Sept. 1875, was 2·07 in.

During the 5 years the glacier has diminished very considerably, especially in its depth. This may account for the slower movement in the last three years. During the past year the boulder has been at a part of the glacier which is steeper than where it was previously. This may explain the slightly accelerated movement during the last year. I do not rely implicitly on the 44 days' observation, but if it be assumed to be correct, it leads to the inference that the movement in summer is 2 in. per day, and in winter 1 in.

In the first four years there was no perceptible disturbance of the position of the boulder on the sustaining ice. During the last year it has twisted a little.

Last summer I took some observations to ascertain the superficial waste of the glacier on a part which was free from moraine (during fine sunny weather), and found it amount to about 3 in. per day. This summer I have again taken observations, in a different manner, extending over 21 days; these gave a result of over 2 in. per day.

Forbes states that the waste is as much as 3 in. a day in a hot summer. Now on comparing the scale of movement with that of the waste by melting, I get results which I cannot reconcile.

The boulder which I have had under observation cannot have come from any mountain which is less than three miles distant from its present position. The angle of the glacier above the part where it rests, is less, rather than greater. I therefore assume that the recorded rate of movement may be taken as an average, in which case the boulder must have been travelling 400 years.

The depth of the glacier is probably not more than 300 feet, but I will assume it to be 600 feet, and that the average waste is only two inches a day, during three summer months, or fifteen feet per annum. On this assumption the whole depth of 600 feet would be melted in forty years. I have taken observations of the relative movement of the glacier, where covered with moraine, and also where free from it. They do not encourage the supposition that there is any material difference. F. Lloyd.

19*th August*, 1880.

THE PERMANENCE OF OCEANS AND CONTINENTS.

Sir,—Mr. T. M. Reade, in your September Number, quotes certain authors who believe that oceans and continents have, throughout all known geological time, occupied pretty much the same relative positions as now.

There is, however, one important omission in this list. In the famous chapter in the *Origin of Species*, "On the Imperfection of the Geological Record," Mr. Darwin endeavours to account for the sudden appearance of groups of allied species in the lowest known fossiliferous strata; he does this by assuming that the Pre-Silurian continents probably existed where the oceans now are. He says: "We may infer that where our oceans now extend, oceans have extended from the remotest period of which we have any record; and on the other hand, that where continents now exist, large tracts of land have existed, subjected no doubt to great oscillations of level, since the earliest Silurian period. . . . . . At a period immeasurably antecedent to the Silurian epoch, continents may have existed where oceans are now spread out; and clear and open oceans may have existed where our continents now stand." (Quoted from 3rd ed. 1861, p. 335; 1st ed. published in 1859.)

This and similar statements in the same chapter were then regarded as pure assumptions on Mr. Darwin's part, made to evade a difficulty which the author himself admitted "may be truly urged as a valid argument against the views here entertained." The inference in the first half of the quotation given above will probably now be accepted by most geologists; that in the second half may not yet gain so general a belief. The "Record" of Palæozoic life has been carried far back since the publication of the "Origin of Species," but the difficulty remains much as it did, and can probably only be explained in the manner stated by Mr. Darwin.

GEOLOGICAL SURVEY OFFICE, LONDON, *September 25th*, 1880. W. TOPLEY.

POST-GLACIAL.

SIR,—In a letter in your last Number under the above heading, Mr. Dalton referred to the mention of a burnt stone, or what appeared like one, found by me at Lexden brickpit, and argues from it that Palæolithic Man, the contemporary of these great beasts, was, as man is now, a "cooking animal." But this burnt stone, if such it was, was not found in the same stratum with the pachyderms, but in brick-earth overlying it. I believe I made this sufficiently clear in my paper upon the deposit (Quart. Journ. Geol. Soc. 1863, p. 396).

I am rather disposed to think that this brick-earth is considerably more recent than the peat, in and beneath which the bones of elephants and rhinoceroses were so abundant. O. FISHER.

HARLTON, CAMBRIDGE, 6 *Nov.*

"FOSSILS OTHERWISE THAN ON BEDDING PLANES."

SIR,—Since the appearance of my letter in your September Number, I have been confirmed in my view by several other observers, and I would especially mention two who have kindly furnished me with definite instances in point. Mr. Ussher lately sent me a specimen from the Lower Lias near Newark, showing *Ammonites planorbis* occurring nearly vertically to the bedding; and by this morning's post (Oct. 26th) I have received from the same locality, through the kindness of Mr. Dalton, a drawing of two specimens of *Ammonites semicostatus* traversing the bedding, the one at an angle of about 45°, the other at an angle of about 30°.

I have already suggested what appear to me certain *veræ causæ* for the occurrence of fossils in such positions. I will only now add that if conditions should hereafter supervene which should alter the character of these Liassic beds, obliterating the bedding and superinducing cleavage, rendering them in fact mineralogically similar to the Silurian slates before referred to, the only fossils visible in them would as a rule be those which happened to coincide with the cleavage planes. W. DOWNES.

KENTISBEARE, COLLUMPTON, *October 26th*, 1880.

OBITUARY.

SEARLES VALENTINE WOOD, F.G.S.

BORN FEB. 14TH, 1798; DIED OCT. 26TH, 1880.

MR. WOOD was born on St. Valentine's Day, 1798, hence his name. He went to sea as a midshipman in the "Thames" (one of the East India Company's mercantile fleet) in 1811; and continued in that service until the year 1826, when, being disappointed in obtaining the command of a ship that had been promised him, he retired from a maritime life, and devoted himself to palæontological studies. Settling in his native place in Suffolk, he gave the larger part of his attention to the Crag, but he collected extensively from the Hampshire Tertiaries; and for the purpose of working out the relation of these to the beds of the Paris basin, he formed an extensive collection of the French Eocene Mollusca.

From these materials, and from correspondence with Deshayes and other French *savans*, he was prepared to have taken up the description of the English Eocene Mollusca long before he actually did so, circumstances having determined his undertaking the description of the Mollusca from the Upper Tertiaries first. He also formed a considerable collection of recent Mollusca for comparison in working out the relations of the Mollusca from Tertiary formations. Having left Suffolk from ill-health, and settled in London, he was in 1837 introduced to Sir Charles (then Mr.) Lyell; and was associated with him in the endeavour in which Lyell was then mainly engaged, to work out a better knowledge of the Tertiary formations, which up to a period not long before that time had been regarded as of small account, in comparison with the "Secondary" group. In this task Lyell relied principally on S. V. Wood and the late G. B. Sowerby for the determination of the identity of the Molluscan remains from various countries with those found fossil in England, and with the Molluscan fauna living in existing seas, as far as these were then known. Mr. Wood also for a few months about this time acted as Curator of the Museum of the Geological Society.

Urged to the task by Lyell, he commenced (with the co-operation of the present G. B. Sowerby as engraver and intended publisher), the description of the "Crag Mollusca"; and considerable progress having been made with the manuscript and plates of the first, or "Univalve" part of this work, when the Palæontographical Society was formed in 1847, this part formed the first volume of the magnificent series of scientific publications which have been issued by that Society. The rest of the "Crag Mollusca" followed in subsequent years; and upon the completion of this work, and in recognition of his labours generally in connexion with the Tertiary Mollusca, the Council of the Geological Society awarded to Mr. Wood in the year 1860 the Wollaston medal. A large supplement to this work, embodying the discoveries which had subsequently accumulated, was prepared by Mr. Wood; and this, accompanied by an introduction describing geologically the formations from which the remains embraced by the work had been obtained, from the pen of his son and of Mr. F. W. Harmer, was issued by the Palæontographical Society, in 1871 and 1873. A second supplement followed this in 1879, and Mr. Wood was actively engaged up to the day of his seizure with fatal illness on another small addition. On the completion of the description of the Molluscan remains from the Crag, Mr. Wood presented the unrivalled collection of them, which he had been forming during thirty years, to the nation; in order that, by being preserved intact in the British Museum, the types of all the forms which had been described and figured by him in his work (save two or three which belonged to other persons), might be available for examination and comparison by naturalists engaged in similar labours.

He also presented to the nation the valuable collection of vertebrate remains (including among them the unique jaws of *Alligator Hantoniensis*, and *Microchœrus erinaceus*), which he had in 1843-5 extracted from the Eocene Freshwater beds of Hordle Cliff; and from which beds up to the time when he commenced to form this collection no such remains had been known. These he partially figured and described in the London Geological Journal; but the stoppage of that publication brought this part of his labours to an unexpected termination. In 1858, having the advantage of an unrestricted manipulation of the more extensive collection of Eocene Mollusca which had been formed by his friend F. E. Edwards, he commenced the description of the Eocene *Bivalvia*, Mr. Edwards taking upon himself (and having commenced before this) the *Cephalopoda* and *Gasteropoda;* and several parts of this work were issued by the Palæontographical Society. Failure of health put a somewhat premature period to Mr. Edwards' share in this work, but Mr. Wood continued his share for some years longer, relinquishing it only when, shortly before Mr. Edwards' death, this collection was acquired by the British Museum. During the time in which it remained in Mr. Edwards' possession he was accustomed to place in Mr. Wood's care, for study at his leisure, all specimens he possessed which in any way illustrated the subject in hand, but this the transfer of the collection to the British Museum rendered impracticable; and as it was Mr. Wood's feeling that in addition to that opportunity for careful study, all forms as to which any doubt existed ought to be carried abroad and compared with those in the Museums of France and Belgium, if justice was to be done to the subject, and as at his advanced age he was unable to accomplish this, he on the issue of the part in the volume of the Palæontographical Society for 1877 relinquished the further prosecution of the "Eocene Bivalvia," though he subsequently added a small contribution (both to Mr. Edwards' and his own portion) on special groups of Eocene Mollusca, which he was able to do from resources afforded by his own collection and the collections of some friends.

He maintained his activity both of mind and body up to the day of his seizure with fatal illness, which took place on the 21st, and terminated with his death on the 26th of October last. He was buried in the churchyard of Melton, near Woodbridge, in view of the Crag of which the study had occupied so much of his life.

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